The Regional Innovation System–University–Science Park nexus: University roles within an emerging peripheral region developing-economy innovation system. A study of the Chiang Mai University (CMU) Science Park in Northern Thailand

Sponsored by The Royal Thai Government Scholarship

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Submitted November 2019

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This thesis is submitted in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy of the University of Portsmouth

Declaration

This thesis is submitted to the University of Portsmouth for the degree of Doctor of Philosophy.

Whilst registered as a candidate for the above degree, I have not been registered for any other research awards. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

This dissertation is the result of my independent work/investigation, except where otherwise stated. A reference list is appended.

I hereby give consent for my dissertation, if accepted, to be available for photocopying and inter-library loan, and for the title and summary to be available online.

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Signed.......... ....

Thunyanun Theera-Nattapong

Thesis word count: 74,882

Acknowledgements

First of all, I would like to especially thank my director of studies, Professor David Pickernell, for his invaluable guidance, ideas and encouragement. Without his excellent supervision and patience, this project would not have been completed. I would also like to thank my second supervisor, Dr Christopher Simms, for his suggestions, feedback and support throughout the last few years. Additionally, I would like to express my gratitude to Professor Paul Trott for inspiration since I started this project.

I am also appreciative of the Royal Thai Government, who sponsored my PhD study in the UK. My sincere thanks goes to those individuals who participated in this research project, and I am especially thankful to Mrs Nattaya Chunhawiriyakul who helped me coordinate with all the entrepreneurs and executives of the Science and Technology Park of Chiang Mai University. Also, I would like to extend particular thanks to all policy and planning analysts at the Science Park Promotion Agency.

My thanks go to my PhD friends in Portsmouth, especially Miss Sasikarn Howchatturat and Miss Anchalee Anchaleerat, for their goodwill and emotional support. I would further like to thank my personal fitness trainer, Siriwan, and massage therapists for helping me to improve my health and wellness.

Last but not least, I would like to convey my deep appreciation to my beloved parents, Nalinrut and Jeerawat Theera-Nattapong, and my grandmothers for their unconditional love and support throughout my life.

Abstract

Many previous studies have evaluated the roles of universities within Regional Innovation Systems (RIS). However, few studies have linked the literature on RIS and science parks, which has led to less emphasis being placed on the roles of the university within the RIS–university–science park nexus. In addition, these studies have tended to either have a peripheral region developed-economy or core region-developing economy focus, with a lack of studies on the peripheral region developing-economy context. The purpose of this thesis, therefore, is to investigate the roles of the university and its relationships within the RIS–university–science park nexus within the specific peripheral region developing-economy context of the RIS of Northern Thailand (NT-RIS). It also identifies the roles of the university in the actual innovation process – which is an additional gap in the existing literature – providing evidence of how universities and science parks contribute to the development of a peripheral region RIS in a developing-economy context.

This thesis contributes to knowledge in two main aspects. The first contribution is through developing a two-dimensional, nine cells, matrix from a systematic literature review, which can be applied to identify the roles of the university in RIS–university, RIS–university–science park and the university–science park interrelationships in developed, developing, core and peripheral economy contexts. By applying the matrix, the unique characteristics of the roles of the university in the peripheral region developing-economy context of the NT-RIS are identified, providing a contribution to knowledge in terms of the specific roles emphasised in this under-researched context and what is different about a university in a science park in a peripheral region compared to a core region. Specifically, in addition to identifying the relative weakness of many of the cells in comparison with the literature (which is based on mainly focused on developed and/or core economy contexts), the specific roles emphasised in this under-researched context are: (i) building regional networks, (ii) research collaboration, (iii) knowledge intermediaries, and (iv) promoting the commercialisation of research results. The results highlight that because the university is relatively new to the role of

the entrepreneurial university, the NT-RIS is largely still nascent, and firms have capacity issues, the university is having to address simultaneously supporting innovating firms with capacity-building activities.

In also identifying the roles of the university in the actual innovation process, the research provides its second main contribution to knowledge, identifying in detail the specific innovation processes at work. The findings from the 12 cases uncovered that the university in the peripheral region developing-economy NT-RIS supports four specific processes. These four broad processes were identified by comparing the interactive innovation processes of each case study to reveal how Chiang Mai University (CMU) is playing roles to support firms, the characteristics of the four processes, as well as project outcomes. These processes were focused on the: (i) research relationship process (three cases), (ii) product development process (two cases), (iii) knowledge transfer process (five cases), and (iv) innovation impact process (two cases). As part of these findings, three specific university-provided innovation success-driving factors were identified which were particularly associated with more successful outcomes of the innovation process as perceived by the firms themselves – also helping to answer how the university contributes to on-park firms in the context of a peripheral developing economy. These three factors were related to pre-STeP programme training, CMU researchers acting as knowledge intermediaries in organising external experts to participate in research collaboration, leading to further sharing of knowledge and ideas, and the provision of intellectual property (IP) training to firms. These results also support the developmental state of the RIS. In using the research to identify the roles of the university in developing the RIS itself in this peripheral region developing-economy context, through the innovation process, this second contribution to knowledge is reinforced. The university is found to have a more developed input (than identified in previous literature) in terms of innovation activities through its relationship with the science park, including a greater and more direct role in product development, providing IP management and training to a greater extent than that emphasised in previous literature focused on the peripheral RIS of developed countries. Unsurprisingly, the interactions in the NT-RIS have evolved in a similar manner to the interactions in RIS in the core regions of other developing economies, the RIS in

Northern Thailand focused on the 'core area' of the peripheral region (Chiang Mai), but on a clustered sector (agri-food), which is different from that of other studies. Additionally, because the RIS in Northern Thailand is in the developing phase, the interactions and coherence among actors overall have been more limited and developmental than in the contexts focused on in previous literature.

This thesis also contributes to practice. Specifically, the matrix can be applied to other regions, in developed, developing, core and peripheral economy settings, allowing them to compare their activities against the matrix in order to see what they may need to develop, as well as offering contributions to practice in the Thai-specific context. In addition, in terms of policy-related recommendations, because the findings demonstrate limitations in the current functioning of the Thai national innovation system and Northern Thailand RIS, it also highlights supportive policies that are still required.

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Abbreviations

B2G Business to Government

CAMT College of Art, Media and Technology

CMU Chiang Mai University

DSL D-Saccharic acid-1,4 lactone

EU European Union

GDP Gross Domestic Product

GRP Gross Regional Product

HEI Higher Educational Institution

IP Intellectual Property

IRTC programme Industrial Research and Technology Capability development programme

IRTU Industrial Research and Technology Unit

IT Information Technology

MOST Ministry of Science and Technology

NIS National Innovation System

NT programme New Technology Programme for Northern Norway

NT-RIS RIS of Northern Thailand

NTBFs New Technology-Based Firms

OEM Original Equipment Manufacturer

PR Public Relations

R&D Research and Development

RIS Regional Innovation System

RQ Research Question

RSPs Regional Science Parks

SME Small and Medium-Sized Enterprises

SP Science Park

SPA Science Park Promotion Agency

STDB Science and Technology Infrastructure Database

STeP Science Park of Chiang Mai University

STI Science, Technology and Innovation

STIP Science, Technology and Innovation Park

THU Tsinghua University

TSS Total Soluble Solids

TTOs Technology Transfer Offices

TLO Technology Licensing Office

UK United Kingdom

USA United States of America

WIFI Wissen Ist Für Immer

Chapter 1: Introduction

The Regional Innovation System (RIS) consists of firms, institutions and knowledge infrastructure (such as science parks) linked together within the region, emphasising the interactive learning amongst them (Cooke, Gomez Uranga, & Etxebarria, 1997; Doloreux, 2002). As actors in the RIS, science parks generally act as an intermediary organisation to connect universities and firms (Minguillo & Thelwall, 2015), while universities have been seen to predominantly have the role of knowledge creator, generating new knowledge for the system (Lew, Khan, & Cozzio, 2018). There have, however, been limited numbers of prior studies focusing on the roles of the university in its relationships within the RIS–University–Science Park nexus in peripheral RIS of developing economies. This thesis applies the concept of RIS to the specific interrelations between RIS actors, Chiang Mai University (CMU) and the Science and Technology Park of CMU (STeP) in Northern Thailand, addressing research gaps and making contributions to both knowledge and practice.

1.1 Theoretical background

There has been increasing interest in the concept of the 'entrepreneurial university', which expands the missions or traditional roles of universities from teaching and research to also include economic and social development (Etzkowitz, 2003). While not a new concept – the *Bayh Dole Act* in 1980 being a policy action towards universities exploiting their knowledge in the United States of America (USA) (Geuna & Rossi, 2011) – the entrepreneurial university concept that universities are adopting has meant that the two traditional roles of universities have been reframed (Etzkowitz & Leydesdorff, 1999; Gunasekara, 2006; Malairaja & Zawdie, 2008). The entrepreneurial university concept aimed to develop the regional economy by bringing universities together with industry and the state (Etzkowitz & Leydesdorff, 1996; Gunasekara, 2006) through the concept of the triple helix (Etzkowitz & Leydesdorff, 2000). This enabled universities to participate in entrepreneurial and business activities, such as through offering research funding, training partnerships and technical services contracts (Malairaja & Zawdie, 2008).

Due to universities already having academic and technical researchers, firms in cooperation with universities can enhance their competitiveness (Storey & Tether, 1998). Moreover, local authorities have also sometimes played an essential role in encouraging universities to take a more active role in the revival of local economies (Lindelöf & Löfsten, 2003, 2006). As a result of the alterations to the roles of universities, policymakers and governments have been anxious to use universities to build the knowledge-based economy and foster regional competitiveness – especially in terms of their roles in the RIS.

Since the early 1990s, and inspired by the concept of the National Innovation System (NIS) in terms of systemic dimensions, the concept of the RIS has highlighted the importance of interactive learning, the role of institutions, and differences in innovation performance and economic growth (Asheim & Coenen, 2006; Cooke, 2001; Cooke, Gomez Uranga, & Etxebarria, 1997). Chung (2002) defines an RIS as consisting of actors and institutions within a region that are directly related to generating, diffusing and exploiting technological innovation and characterising the interrelationships between these innovation actors. Therefore, the RIS has been focused at the regional level, while containing the same components as the NIS including groups of the three main innovation actors, namely universities, industrial enterprises and public research institutions (Chung, 2002).

Within the regional innovation approach, the development of the 'entrepreneurial university' concept and knowledge spillovers (where knowledge from universities in a new organisational form can be commercialised through mechanisms such as start-ups, both in regional economic and social development contexts) have been the focus over the last 20 years (Acs, Braunerhjelm, Audretsch, & Carlsson, 2009; Etzkowitz & Leydesdorff, 1996, 1999). For example, the University of Twente was used as a case study for emphasising how the university has evolved and become differentiated, allowing general reflection on the RIS (Rip, 2002). Moreover, interrelations between actors to produce innovation and foster the learning process in the region are key concepts of the RIS, requiring universities to expand and update their research agendas to meet industrial needs and enhance links with industry (Vedovello, 2002).

RISs, however, exhibit differences by region, depending on individual actors, innovation processes among actors and industrial specialisation. Previous research indicates that peripheral regions' RIS are usually weaker (than those in the core) because their innovation activities mainly focus on incremental and process innovation, networks between actors are limited and organisational thinness consequently exists (Asheim, Moodysson, et al., 2011; Isaksen, 2001; Tödtling & Trippl, 2005). Even though universities often have key roles in such peripheral RIS, only a limited number of prior research studies focus on these roles of the university and its relationships with other actors, with a particular gap in peripheral developing-economy contexts. Therefore, this thesis contributes to knowledge by exploring the roles of the university in peripheral RIS, but with an emphasis on the roles they perform at the nexus between the RIS, university and science park.

The reason for this focus is that science parks are property-based policy interventions specifically designed to support commercialisation of research results from universities and are used as a regional development policy tool (Appold, 2004; Kang, 2004; Quraintas, linear, & Massey, 1992; Vedovello, 1997). The location of the science park is normally established near a higher educational institution (HEI) or university, allowing academic researchers to commercialise research results and exchange knowledge with firms located in the science park; being adjacent to university locations makes the science park a crucial resource network for new technology-based firms (NTBFs) (Westhead, 1997). This close relationship between academic researchers and entrepreneurs is thought to be the main determinant in encouraging the science park as an interactive mechanism for systemic university–industry cooperation (Asheim & Coenen, 2006; Vedovello, 2002). In addition, links between academia and industry have become important for local and regional policymaking (Harper & Georghiou, 2005).

In the literature on both RIS and science parks, universities are therefore key components in RIS and have important linkages with science parks, which are often considered to be integrated within the RIS. As highlighted previously, despite the university being a main actor in the RIS, there are a limited number of prior studies focusing on the roles of the university and its relationships with other actors in the RIS, particularly in peripheral-economy contexts. More specifically, only a limited number of studies link science parks to RIS exist, highlighting another gap in the literature.

This thesis therefore aims to investigate the roles of the university and its relationships within the RIS–University–Science Park nexus in the specific RIS of Northern Thailand (NT-RIS), highlighting the specific context contribution because this thesis illustrates the roles of the university through its relationships with actors in a peripheral RIS of a developing-economy country. In sum, this thesis is built upon the literature on the 'science park' and the 'RIS emphasis incorporating the science park', linking both streams of literature together to bridge the gaps.

1.2 Overview of the limitations in the literature

To construct this thesis, a 'systematic literature review' approach was adopted in order to provide the protocols that the researcher was searching for, mapping and accessing the relevant fields of research, as well as reporting the findings and identifying the gaps in specific literature (Macpherson & Holt, 2007; Tranfield, Denyer, & Smart, 2003). By conducting a systematic literature review, gaps in the literature on studies with an 'RIS–Science Park emphasis' and on 'science parks' were identified:

- First, there have been few studies that link the literature on science parks and RIS, leading to the necessity of creating an overarching framework within which to examine the role of the university in the science park within the context of a specific RIS.
- Secondly, a gap found in the science park literature highlighted no general theory on science parks because of the origins of the parks being different depending on several factors related to the context of each country, such as location, political and social context, and economic system, with a specific lack of literature examining peripheral regions in developing-economy contexts. Consequently, this thesis addresses this gap by applying the framework created to identify the roles of the university during its RIS–university, RIS–university–science park, and university–science park relationships, within a peripheral region developing-economy context.
- Thirdly, only a limited number of studies focus on identifying the roles played by the university during its relationships with the other actors in the actual innovation process itself, with again a specific gap in the peripheral region developing-economy context. Hence, this thesis looks at these roles, including relationships which again will have specific national or regional contexts.
- Lastly, a limited number of studies illustrate how the role of the science park, particularly through interactions with the university, could help further develop the RIS itself, particularly in the peripheral region developing-economy context. To address this gap, this thesis examines the specific roles and activities of the RIS, university and science park actors that are most helpful in RIS development in the peripheral region developing-economy context.

1.3 Scope of research and research questions

This thesis examines the interactions between RIS actors, CMU and STeP in Northern Thailand as an example of a specific RIS. Prior studies that have provided insights into the roles of universities within a peripheral RIS are mostly conducted in developed-economy contexts. Conversely, those studies that have examined RIS within developing countries are largely confined to China and focused on central or core regions. Additionally, due to there being a limited number of prior studies focusing on RIS in Thailand (e.g., Schiller, 2006; Intarakumnerd & Schiller, 2009) – all of which have primarily examined the links between the university and industries of various regions, and thus lack an emphasis on the roles of the university and its RIS–university–science park actor relationships – this context is also considered appropriate. As the emphasis of this thesis is on the relationships among actors in the peripheral RIS of a developing-economy country, Northern Thailand was also selected because it is the only peripheral region in Thailand in which firms collaborate with the science park and university, and commercialise new products from collaborative projects in Thailand and international countries. Having identified Northern Thailand as the geographical focus of the study, four main research questions (RQs) are provided as follows:

RQ 1: What are the specific roles of the university and relationships between the RIS, university and science park actors?

RQ 2: What are the specific roles of the university and relationships between the RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?

RQ 3a: What are the roles of the university in its relationships between the RIS, university and science park actors in innovation projects conducted with on-park firms?

RQ 3b: How does the university contribute to the innovation activities of on-park firms in the context of a peripheral developing economy?

RQ 4: How does the university and science park contribute to the development of a peripheral RIS in a developing economy?

1.4 Research objectives

This thesis therefore explores the roles of the university and the relationships between the actors in the RIS–university–science park nexus. Also, it demonstrates the differences and similarities between the roles of the university in the specific region of Thailand chosen as the focus of the study and those from the existing literature.

Thus, the four objectives of this research are:

1) To develop a framework identifying the roles of the university during its RIS–university, RIS–university–science park, and university–science park relationships.
2) To apply the framework identifying the roles of the university during its RIS–university, RIS–university–science park, and university–science park relationships within a peripheral region developing-economy context.
3) To use the framework to identify the roles of the university in the actual innovation process, through the linkages between actors and the factors affecting the roles of the university within a peripheral region developing-economy context.
4) To contribute to and link together the literature on science parks–RIS and the roles of the university, by providing evidence from the RIS–university–science park nexus within a peripheral region developing-economy context.

The summary of the research gaps, the objectives of this thesis, research questions and contributions to both knowledge and practice are provided in Table 1.1.

Table 1.1 Summary of research gaps, research objectives, research questions and contributions to both knowledge and practices

Research gaps	Research objectives	Research questions	Contributions to knowledge	Contributions to practice
1) Few studies link the literature on science parks and RIS	1) To develop a framework identifying the roles of the university during its RIS–university, RIS–university–science park, and university–science park relationships.	**RQ 1:** What are the specific roles of the university and relationships between the RIS, university and science park actors?	The first contribution is through the building of a two-dimensional matrix illustrating the roles of the university and relationships between RIS–university–science park actors. The matrix is then used as the conceptual framework/analytical framework to identify the roles and relationships between the science park, university and involved actors in the peripheral region of a developing-economy country (Northern Thailand).	The two-dimensional matrix allows other regions to compare their activities against the matrix to see what they need to work on.
2) No general theory exists related to the science park because the origins of parks are different depending on several factors and the context of each country.	2) To apply the framework identifying the roles of the university during its RIS–university, RIS–university–science park, and university–science park relationships within a peripheral region developing-economy context.	**RQ 2:** What are the specific roles of the university and relationships between the RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?		

Research gaps	Research objectives	Research questions	Contributions to knowledge	Contributions to practice
3) A limited number of studies focus on identifying the roles played by the university during its relationships with the other actors in the actual innovation process, with a specific gap in the peripheral region developing-economy context.	3) To use the framework to identify the roles of the university in the actual innovation process, through the linkages between actors, and the factors affecting the roles of the university within a peripheral region developing-economy context.	**RQ 3a:** What are the roles of the university in its relationships between the RIS, university and science park actors in innovation projects conducted with on-park firms? **RQ 3b:** How does the university contribute to the innovation activities of on-park firms in the context of a peripheral developing economy?	The second contribution is in the identification of the roles of the university in interactive innovation processes, the emphasis on specific processes, and demonstrating how the university and science park contribute to the development of the RIS in a peripheral region developing economy economy context.	Comparing the main interactive innovation processes with those of 12 case studies, the results show 'success-driving factors' of more successful projects. This thesis demonstrates a number of policies of relevance in the promotion of a functioning NIS and RIS in Thailand.
4) A limited number of studies illustrate how the role of the science park, particularly through interactions with the university, could help further develop the RIS in the peripheral region developing-economy context.	4) To contribute to and link together the literature on science parks–RISs, and the roles of universities, by providing evidence from the RIS–university–science park nexus within a peripheral region developing-economy context.	**RQ 4**: How does the university and science park contribute to the development of a peripheral RIS in a developing economy?		

1.5 Overview of the research approach

To address the research questions, this study utilised a three-phase approach preceded by a systematic review. To address the first research question, a two-dimensional matrix was first developed from the systematic literature review approach. The matrix, which forms the conceptual framework for this study, demonstrates the roles of the university and its relationships within the RIS–university–science park nexus. The three phases of the research design were then employed in order to answer the second, third (RQ 3a and 3b) and fourth research questions through qualitative approaches.

1.5.1 Phase one

The first phase was designed to identify, from the two-dimensional matrix, the roles most emphasised for the university in its relationships within the RIS–university–science park nexus, and the policies to promote the roles of the university and the relationships between them and the other key stakeholders in the specific peripheral region developing-economy context of Northern Thailand. It consists of semi-structured interviews, both face-to-face and telephone, with four key groups of informants:

(1) on-park firms (to acquire information about their motivations to collaborate with the science park and university, the received services and the relationship experience with these two actors)

(2) executives of University-STeP (to obtain the perspectives of the roles and interactions between RIS actors-university-science park as well as the involved policy to promote the linkage between these actors)

(3) RIS actors, such as policymakers from the Science Park Promotion Agency (SPA) and spin-off firms (to get information about the interactions and the observed roles played by the university; policymakers in particular can provide details of policies to promote linkages between RIS actors-university-science park)

(4) University researchers (to discuss the roles of the university and its relationships).

1.5.2 Phase two

Phase two was designed to investigate the roles of the university in the actual innovation processes between actors for each project, as well as any factors affecting these roles within a peripheral region developing-economy context. It consists of in-depth cases of more and less successful projects that researchers from the university undertook with firms in STeP programmes to commercialise the research results. The researchers and firms participating in the business incubator and IRTC (Industrial Research and Technology Capability Development) programme were interviewed and asked to identify factors they consider important to the roles of the university in commercialising research results. Also, documentation, such as internal documents of the science park, university and SPA, as well as published reports were also used to supplement the data collection from semi-structured interviews.

1.5.3 Phase three

Phase three was designed to identify the contributions of this thesis that can be generalised concerning the knowledge of the RIS–university–science park nexus. This phase focuses on comparing the data and analysis of the observed roles of the university and its relationships in the specific region of Thailand from phases 1 and 2 with those from the existing literature.

1.6 Structure of the thesis

This thesis consists of seven chapters (see Figure 1.1), including this introductory chapter. The outline of the rest of the chapters are as follows:

Chapter 2 describes a systematic literature review approach in order to review the literature with an RIS–science park emphasis and the literature on science parks more generally. The results of the systematic literature review, generating a ‘broad RIS–university–science park context’, are then reported. The chapter ends with the details of the conceptual framework built from the literature review and the identification of research gaps which link to the research questions of this thesis.

Chapter 3 begins with a review of the 'specific research context', including the RIS of peripheral regions and developing countries in order to help analyse the last research question (RQ4) presented in Chapter 6. The chapter also provides the details of an RIS in the Thai-specific context (a specific RIS of Northern Thailand), highlighting the background data and forming the underpinning of the thesis.

Chapter 4 elucidates and demonstrates the methodology being used in this thesis. It presents the research context and relevance to the research questions, as well as the research design, including ethical considerations and identification of the methodological options, and the techniques and procedures used (e.g., data collection methods, interview instruments, methods for analysis etc.).

Chapter 5 presents the findings from phases 1 and 2 of this thesis. It illustrates the overview of the roles played by the university and its relationships within the RIS–university–science park nexus in Northern Thailand. This chapter also outlines the 12 case studies of more and less successful projects that researchers in the university undertook with firms from programmes of the science park.

Chapter 6 then presents the analysis of the findings from phases 1, 2 and 3, answering RQ2, RQ3 (both RQ3a and RQ3b) and RQ4, and identifies the contributions of the thesis. This chapter indicates CMU's roles and its relationships in the NT-RIS, the 'unique characteristics' of the roles of the university and highlights the 'specific roles' of CMU in its RIS–university–science park relationships in Northern Thailand, answering RQ2. It then illustrates the roles of the university and the relationships between the RIS–university–science park actors in innovation projects undertaken between the university and firms, answering RQ3a, as well as identifying success-driving factors to answer RQ3b. Finally, the thesis answers RQ4 in this chapter.

The thesis is finally concluded in Chapter 7, which underlines the key findings and contributions. Policy implications in relation to the findings of this thesis are also provided in this chapter. Limitations of this thesis and suggestions for future research are then described. The chapter ends with concluding remarks.

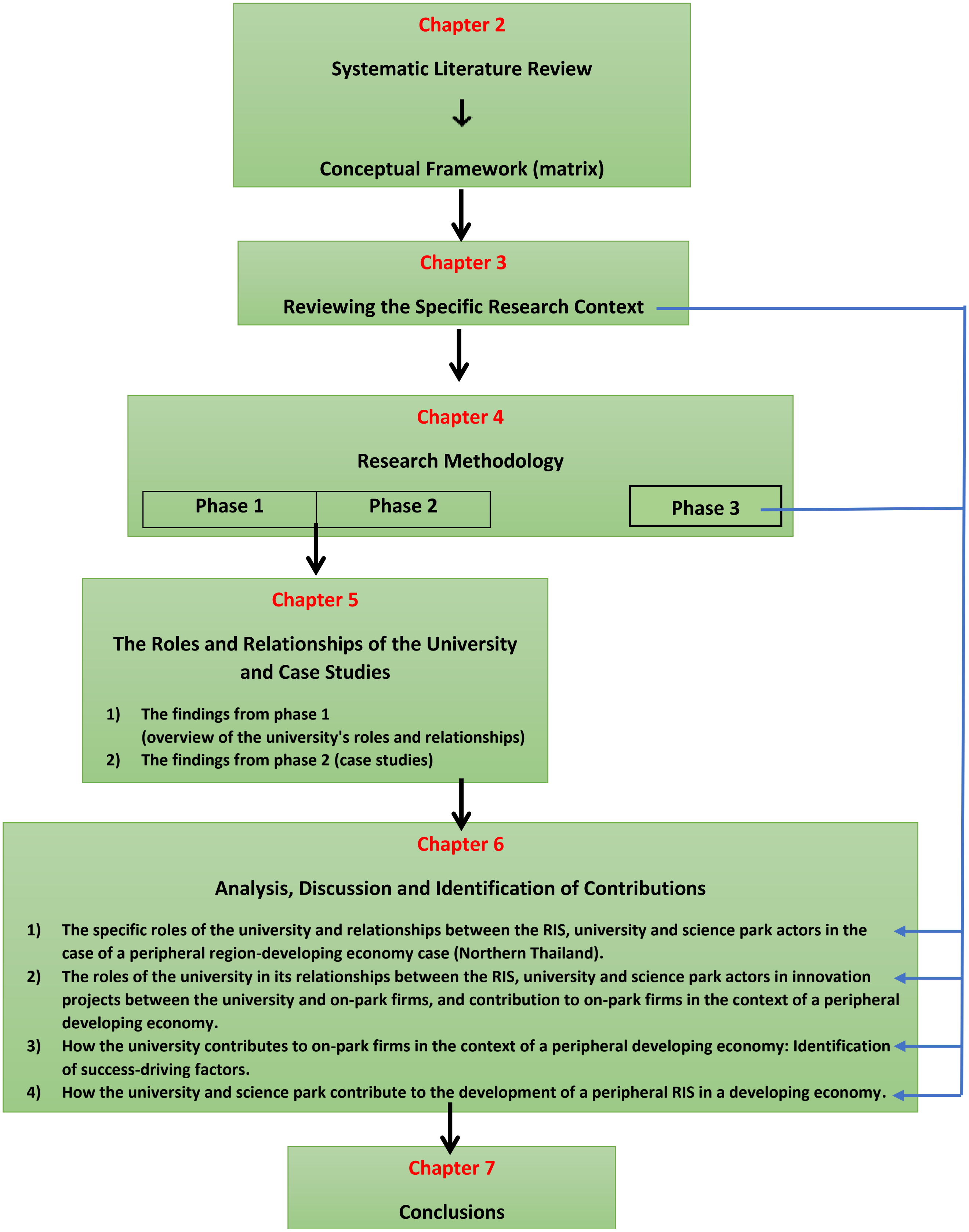

FIGURE 1.1 THE FORMATION OF THE THESIS

Chapter 2: Literature Review and Conceptual Framework

2.1 Introduction

In recent years, policymakers and governments have increasingly been looking to universities to contribute to their local RIS as part of building the knowledge-based economy and fostering regional competitiveness. This has further altered the role of universities. The RIS approach incorporates the development of the 'entrepreneurial university' with knowledge spillovers. This role of the university in regional economic and social development has heavily influenced policy over the past 20 years (Acs et al., 2009; Etzkowitz & Leydesdorff, 1996, 1999).

The interrelationships between the triple helix actors to encourage learning processes in the region also form key aspects of the RIS, which has resulted in universities expanding and updating their research agendas to better meet industrial needs and enhance links with industry (Vedovello, 2002). Consequently, science parks act as an important tool in regional development policy and can be considered as property-based policy interventions to support the commercialisation of university research results (Appold, 2004; Vedovello, 1997).

For example, academic researchers are able to commercialise their research results and exchange knowledge with firms located in the science park. In so doing, science parks offer a crucial resource network for NTBFs (Westhead, 1997). This then both fosters and supplements the role of the science park as an interactive mechanism for systemic university–industry cooperation (Asheim & Coenen, 2006; Vedovello, 2002).

Unsurprisingly, therefore, in both RIS and science park literature universities play a critical role; they form a key and integral component in the RIS and have important linkages with science parks. The key roles performed by universities differ depending on the nature of the interaction and the actor involved. There has, however, been no systematic, integrated investigation into how the roles performed by universities change. Moreover, only a limited number of studies that focus on science parks incorporate the RIS, with even fewer focusing on the university as a key stakeholder within this. This highlights a gap in the literature and this thesis therefore aims to fill this gap.

As this thesis was built upon the systematic literature review approach, the first part of this chapter begins with the description of the reviewing protocol and the selection, grouping and classifying of publications. The next part reports the results of the systematic literature review or broad RIS–university–science park context, including the performance of science parks, the key role of the RIS in resourcing, the key role of the university in brokering knowledge between the RIS and science park, the key role of the science park in exploiting innovation, the university–RIS relationship and its focus on basic research for dissemination, the RIS–university–science park relationship and its focus on product development, the science park–university relationship and its focus on applied research as well as the changing roles of the university in the RIS–university–science park nexus. Then, this chapter provides the details of the conceptual framework grasped from reviewing the literature. Finally, it ends with the identification of gaps found in the literature that link to the research questions of this thesis.

2.2 Systematic literature review approach

This thesis follows a systematic literature review approach constructed from the literature on ‘science parks’ and ‘RIS incorporating science parks’, with the intention of linking both streams of literature. This approach provides a framework of protocols through which the relevant literature is identified, findings reported, and contribution of the study and research gaps identified (Macpherson & Holt, 2007; Tranfield et al., 2003).

In order to be systematic, transparent and replicable, the literature review involved two processes. This follows the approach of Macpherson and Holt (2007), who themselves followed refined protocols outlined by Tranfield et al. (2003) and Pittaway, Robertson, Munir, Denyer and Neely (2004). First, the researcher defined the review protocols and mapped the literature by (i) accessing, (ii) retrieving and (iii) judging the quality and relevance of the literature in relation to the research topic, according to explicit inclusion and exclusion criteria. As part of this, the researcher classified the quality of papers, following Turner, Swart and Maylor's (2013) approach of selecting papers categorised by journal rating (based on the Association of Business School's Academic Journal Guide 2018). This produced the following review protocols and processes, summarised in Table 2.1 and then discussed in more detail below.

TABLE 2.1: SUMMARY OF SYSTEMATIC REVIEW ARTICLES' RETRIEVAL AND ANALYSIS

Stage	Number of documents	Excluded documents	Number of relevant documents
1: Primary Search String Analysis using Inclusion Criteria	1735	646 (Duplicates)	1089
2: Application of Exclusion Criteria	1089	938	151

2.2.1 Review protocols

The papers included in the systematic literature review approach of this thesis were identified from the electronic databases Business Source Complete, Web of Science and Scopus, and were restricted to English-language academic papers in the categories of 'technological innovations, research parks, technology, and business incubators' (Business Source Complete), 'business and management' (Web of Science), and 'business, management and accounting' (Scopus).

Three inclusion criteria were used within the systematic review process. First, papers were included that reviewed secondary data analysis if the purpose of the review was to identify future research or policy agendas because they offered the working assumptions to be used in this thesis, or if they included primary quantitative or qualitative empirical studies.

Second, articles had to be published after 1990. This time period was selected due to the concept of RIS most consistently appearing and being developed during the 1990s, the literature on science parks also most strongly being observed during this period, and also the need to focus on policy developments in the context of these more recent developments. Third, following Savino, Messeni Petruzzelli and Albino (2017), only academic journal articles were included and, therefore, also following Yu and Hang (2010), book reviews, book chapters, conference proceedings and working papers were excluded.

An initial list of keywords based on prior experience was discussed, yielding three keywords. The researcher then conducted Boolean searches on combinations of the identified keywords (and their variants). For example, these searches included 'Science park', 'Research park', 'Technopole', 'High-Tech park', 'Technology park', 'Regional Innovation System' and 'Science park'. The total number of potentially relevant articles retrieved using search strings alone was 1735.

Once duplicate articles were excluded, 1089 papers remained. To then identify the papers directly related to the topic and classify these papers, the papers were evaluated systematically, beginning with the journal quality, then examining the content of the abstract and introduction, literature review, and conclusion in order to exclude irrelevant articles (using the exclusion criteria in Table 2.2).

TABLE 2.2: STAGE 2 EXCLUSION CRITERIA

	Exclusion criteria
The quality of the articles	• Journals rated as 1* or that did not appear in the Chartered Association of Business Schools Journal Guide 2018.

Literature on science parks	• The studies were not relevant to science park OR
	• The studies were tangentially related to science parks, but primarily focused on:
	  • urban planning and city design
	  • intellectual property (IP) management and/or patents
	  • modelling growth and productivity
	  • industrial cluster policy
	  • the effects of government fiscal incentives
	  • venture capitalists
	  • the growth of information technology (IT) industry
	  • the impact of returnee entrepreneurs and their knowledge spillover
	  • recombinant distance
	  • Proof of Concept process

Literature on RISs	• The paper did not describe the concept of the RIS and did not refer to science parks or other names of science parks.
	• The studies were tangentially related to RISs and referred to science parks but primarily focused on:
	  • The relationships of regional innovation initiatives, knowledge-intensive business services and value chain information sources on the acquisition, assimilation, transformation and exploitation learning processes of absorptive capacity
	  • Open Regional Innovation System model
	  • Product innovations in manufacturing industries

2.2.2 Mapping the Field

Utilising the described process, 151 papers were identified as directly related to the topic. Table 2.3 categorises these articles by journal, using ratings from the Chartered Association of Business Schools Journal Guide 2018. A total of 90 papers were published in journals rated as ABS4 or ABS3 (59.60%), while 61 papers were rated as ABS2 (40.40%) (as shown in Table 2.3) according to the numbers of selected papers published in each journal. *Technovation* and the *Journal of Technology Transfer*, unsurprisingly given their focus, demonstrated the strongest discourse around the relevant issues in terms of papers. The average number of papers from 1990 to 2019 was approximately five papers per year, with concentrations for science parks around the years 2003, 2005, 2006 and 2008, and RIS–science parks around the years 2002 and 2005.

TABLE 2.3: JOURNALS AND A NUMBER OF SELECTED PAPERS

Qty. of papers	Journals
33	*Technovation (ABS3)*
30	*The Journal of Technology Transfer (ABS2)*
13	*European Planning Studies (ABS2)*
10	*Research Policy (ABS4)*
7	*R&D Management (ABS3)*
7	*International Journal of Technology Management (ABS2)*
7	*Technology Analysis & Strategic Management (ABS2)*
5	*Regional Studies (ABS3)*
5	*Small Business Economics (ABS3)*
5	*Technological Forecasting & Social Change (ABS3)*
3	*Journal of Business Venturing (ABS4)*
3	*Entrepreneurship & Regional Development (ABS3)*
3	*International Journal of Industrial Organization (ABS3)*
3	*Urban Studies (ABS3)*
2	*Industrial and Corporate Change (ABS3)*
2	*Journal of Small Business Management (ABS3)*
1	*Environment and Planning A (ABS4)*
1	*Environment and Planning D (ABS4)*
1	*Journal of Economic Geography (ABS4)*
1	*Journal of Management Studies (ABS4)*
1	*International Business Review (ABS3)*
1	*Industrial Marketing Management (ABS3)*
1	*Journal of Business Research (ABS3)*
1	*New Technology Work and Employment (ABS3)*
1	*Omega: The International Journal of Management Science (ABS3)*
1	*Asia Pacific Business Review (ABS2)*
1	*Economics of Innovation & New Technology (ABS2)*
1	*Journal of Business & Industrial Marketing (ABS2)*
1	*Journal of Productivity Analysis (ABS2)*
151	***Total***

Focusing on the overlaps in broad topic areas covered by the papers, 119 articles originated from the science park literature. Seventy-one of these papers also indicated the roles and interactions of the university and science park, while 48 focused solely on the science park. The remaining 32 articles had an RIS literature emphasis while incorporating science parks within their analysis (i.e., RIS with a science park emphasis). These articles can be divided into: (i) 18 papers which referred to the science park and asserted the roles and interactions of the university and RIS, (ii) eight papers referring to the science park but focused mainly on the RIS and without the university, (iii) two papers conducting research on the science park and relevant RIS concepts without mentioning the university, and (iv) four papers conducting research focused on the science park and including both RIS concepts and the role of the university.

With respect to the study locations, the literature on science parks without an RIS–science park emphasis is shown in Table 2.4. The results identify a concentration of single-country studies, particularly in Taiwan, the United Kingdom (UK), Sweden, China and Spain. Conversely, the literature with an RIS–science park emphasis (Table 2.5) is relatively more focused on multi-country studies, with again an unsurprisingly strong focus on more developed economies.

TABLE 2.4: THE STUDY LOCATIONS IN THE LITERATURE ON SCIENCE PARKS WITHOUT REFERENCE TO AN RIS–SCIENCE PARK EMPHASIS

Country	**No. of papers**	**%**
Taiwan	13	10.924
UK	13	10.924
Sweden	11	9.244
China	10	8.403
Spain	10	8.403
Two countries	8	6.723
Italy	7	5.882
N/A	7	5.882
USA	6	5.042
Japan	3	2.521
European countries	2	1.681
France	2	1.681
Germany	2	1.681
Greece	2	1.681
Malaysia	2	1.681
Portugal	2	1.681
Singapore	2	1.681
South Korea	2	1.681
Australia	1	0.840
Brazil	1	0.840
Canada	1	0.840
Finland	1	0.840
Hong Kong	1	0.840
Hungary	1	0.840
India	1	0.840
Israel	1	0.840
Kazakhstan	1	0.840
Russia	1	0.840
Saudi Arabia	1	0.840
South Africa	1	0.840
Thailand	1	0.840
Turkey	1	0.840
More than three countries	1	0.840
Total	**119 papers**	

TABLE 2.5: THE STUDY LOCATIONS IN THE LITERATURE WITH AN RIS–SCIENCE PARK EMPHASIS

Country	**No. of papers**	**%**
Two countries	6	18.75
Italy	3	9.375
Three countries	2	6.250
Canada	2	6.250
China	2	6.250
N/A	2	6.250
Norway	2	6.250
Spain	2	6.250
Sweden	2	6.250
Australia	1	3.125
Austria	1	3.125
Germany	1	3.125
Greece	1	3.125
Japan	1	3.125
More than three countries	1	3.125
South Korea	1	3.125
The Netherlands	1	3.125
Turkey	1	3.125
Overall	**32 papers**	

Finally, in terms of the analytical focus of the papers (shown in Table 2.6), secondary review papers equal the mixed-method papers, with each accounting for 10.60% of the total. There is a relative concentration on qualitative over quantitative studies, particularly for RIS with a science park emphasis, while most of the mixed-methods papers are focused on science parks.

TABLE 2.6: A SUMMARY OF THE ANALYTICAL FOCUS OF THE PAPERS

	Secondary review papers focused on future research/ policy agenda (%)	**No. of mixed-method papers (%)**	**No. of qualitative papers (%)**	**No. of quantitative papers (%)**
Science park without reference to RIS–science park emphasis Overall = 119 papers	12 (10.08%)	15 (12.61%)	44 (36.97%)	48 (40.34%)
RIS–science park emphasis Overall = 32 papers	4 (12.50%)	1 (3.125%)	20 (62.50%)	7 (21.875%)
Total 151 papers	16 (10.60%)	16 (10.60%)	64 (42.38%)	55 (36.42%)

2.2.3 Reporting the findings

The systematic literature review approach of this thesis therefore followed processes similar to Macpherson and Holt (2007), first providing a broad descriptive review of the literature (Tranfield et al., 2003) according to the broad RIS–university–science park framework on which the data had been initially collected to identify the context. Following this, the researcher undertook continuous inductive and iterative coding and sensemaking processes (Williams, 2002), comparing the literature to generate summarising themes through which to identify the different roles of the university in the RIS–university–science park nexus and produce a conceptual framework/an analytical framework.

2.3 The broad RIS–university–science park context

2.3.1 The performance of science parks

Science parks clearly aim to generate the growth of NTBFs; on-park firms are expected to 'perform better' or benefit from greater 'added value' than equivalent off-park firms (Löfsten & Lindelöf, 2002; Radosevic & Myrzakhmet, 2009). However, the performance of science parks or on-park firms especially in relation to survival, wealth creation and employment growth has been difficult to define with appropriate measure(s) (Markman, Siegel, & Wright, 2008). To explore effectiveness, some researchers have therefore compared on-park with off-park firms in terms of: innovative performance (Chan, Oerlemans, & Pretorius, 2010; Lindelöf & Löfsten, 2003; Löfsten & Lindelöf, 2001; Radosevic & Myrzakhmet, 2009), facilities management (Dettwiler, Lindelöf, & Löfsten, 2006), research and development (R&D) productivity of firms (Siegel, Westhead, & Wright, 2003a; Yang, Motohashi, & Chen, 2009), the performance of firms (Löfsten & Lindelöf, 2003), product development (Lindelöf & Löfsten, 2004), perceived benefits of a science park location (Westhead & Batstone, 1998), survival and growth rates (Ferguson & Olofsson, 2004), improvement in economic performance and innovative capacity (Liberati, Marinucci, & Tanzi, 2016), contribution to NTBFs (Fukugawa, 2006), links with local HEIs (Westhead & Storey, 1995), R&D 'inputs' and 'outputs' (Westhead, 1997), innovative output (Squicciarini, 2008), university–industry collaboration (Malairaja & Zawdie, 2008), performance of NTBFs (Siegel, Westhead, & Wright, 2003b), the effect of location in science and technology parks on firms' absorptive capacity (Ubeda, Ortiz-de-Urbina-Criado, & Mora-Valentín, 2019), the role of science parks as locations fostering local knowledge exchange and promoting innovation (Díez-Vial & Fernández-Olmos, 2015), the effect of economic recession on the performance of firms located in science or technological parks (Díez-Vial & Fernández-Olmos, 2017), the impact of science parks on growth and innovativeness (Lamperti, Mavilia, & Castellini, 2017), the effect of science parks in fostering the establishment and growth of NTBFs (Colombo & Delmastro, 2002), analysing the influence of science and technology parks on cooperation for innovation (Vásquez-

Urriago, Barge-Gil, & Modrego Rico, 2016) and the effects of science parks on the innovation performance of NTBFs (Ramírez-Alesón & Fernández-Olmos, 2018).

Given this plethora of potential performance measures, there are also, unsurprisingly, many identified determinants of science park performance. For example, a strong management team is recognised as a characteristic of successful science parks (Cabral, 2005). Albahari, Catalano and Landoni (2013) introduced a framework to analyse science park systems. Applying it to the Italian and Spanish contexts, they found that science parks played a more essential role in Spain than in Italy because of the more coherent and specific policies supporting the parks, sounder business models and government intervention in the medium–long term.

Guadix, Carrillo-Castrillo, Onieva and Navascués (2016, p. 4870) define successful science parks as *'the parks that have overcome the initial stage and handle high revenue volumes, high rates of land occupation, and a large number of employees'*. The availability of R&D centres and academic institutions that encourage the development of specialised knowledge for use by firms and the transfer of knowledge among various organisations are crucial, as demonstrated in the case of Sophia Antipolis (Barbera & Fassero, 2013). Conversely, Eto (2005) indicates that technoparks in Japan, located in rural areas far from train stations, highlight obstacles to promoting high/new technology parks. Thus, it is unsurprising that 53 technology parks in China are located in the largest cities and metropolises, where resources and industrial capability are available (Hu, 2007).

Science park performance can therefore be seen to be at least partly the result of public–private partnerships, with multiple organisations involved in influencing their mission and operational procedures (Phan, Siegel, & Wright, 2005). Government support is therefore an important factor in determining the likelihood of success. For example, studies in Japan (Xue, 1997; Park, 2004) have demonstrated the importance of central and local governments in supporting the development of science parks through active involvement, national and research institutes, and strategies to promote industrial R&D. Likewise, the success of BIORIO in Brazil was attributed to dynamic government funding, alongside research-orientated institutions and a research-orientated private sector (Cabral & Dahab, 1998). Vaidyanathan (2008) also identified the key role of the Indian Government's business model, which fostered links between public, private and foreign sectors. To be successful, Etzkowitz and Zhou (2018) therefore conclude that science parks must be present in the interrelationships among university–industry–government in a region. These findings reinforce the importance of the wider RIS to science park success.

Beginning with the broad RIS–university–science park framework in which innovation takes place, two basic categories of analysis were identified, namely the main roles and focus of each of the key stakeholders and the relationships between these stakeholders.

2.3.2 The key role of the RIS in resourcing

According to Buesa, Heijs, Martínez Pellitero and Baumert (2006), the RIS acts as a set of public and private organisations forming a network and interacting to create and spread knowledge and innovation within a specific territory. Articles that fall within the study parameters emphasise the importance of this RIS context. Specifically, this context acts as a trigger to defining what can or cannot be achieved. Hence, alongside government support, the university's role and the science park's functions and performance crucially depend on the RIS – the implication being that, otherwise, these functions will not operate optimally.

The concept of the RIS highlights the importance of a range of institutions, national and local policies in human resource development, local government and designation of land development, which can include high-tech parks, science and industrial parks (Zhang, 2015). This supports interactive learning and helps explain differences in regional innovation performance and economic growth (Asheim & Coenen, 2006; Cooke, 2002; Cooke, Gomez-Uranga, et al., 2003). Asheim and Coenen (2005) also identify the importance of fostering 'regional culture' in the development of an RIS, with dynamics eventuating not only from general economic processes but also sociological circumstances relevant to knowledge production and the uptake of new knowledge (Rip, 2002). A dense inter-organisational network within a region is therefore key to encouraging knowledge diffusion, regional learning and effective resource transfer within the RIS (Takeda, Kajikawa, Sakata, & Matsushima, 2008), specifically when surrounded by supporting innovative agencies (Asheim & Isaksen, 2002). Lew et al. (2018) also highlight the importance of international connections of regional innovation actors, strong government innovation policy initiatives and regional R&D collaboration.

Central to the RIS approach, therefore, is to recognise the region as a network of connected actors, built up by regional resources within the network, allowing knowledge to be transferred across agents within a region (Cantner, Meder, & Ter Wal, 2010). This is supported by strong regional governance, defined as the capacity to develop the policies and organisations required (Cooke et al., 1997). To design a sustainable RIS, researchers indicate that resourcing the development of relevant infrastructure is one of the criteria necessary for success, with the infrastructure itself an essential determinant for firm location choice (Gerstlberger, 2004; Takeda et al., 2008).

2.3.3 The key role of the university in brokering knowledge between the RIS and science park

Universities have been identified as a major component of the RIS, and they play a crucial role in brokering knowledge (Chung, 2002; Gunasekara, 2006; Kramer, Marinelli, Iammarino, & Diez, 2011; Lew et al., 2018), which differs to other parts of the RIS. While universities are often crucial actors in their regions in terms of employment and economic activity (Löfsten & Lindelöf, 2005), they play an important role as both direct and indirect sources of knowledge production, which they are able to feed or diffuse into the RIS (Cooke, 2002; Lew et al., 2018).

Universities are therefore particularly important in both the knowledge generation and diffusion subsystem of the RIS, as well as in subsequent knowledge application activities and connections with firms that aim to exploit the knowledge for commercial returns (Cooke, 2002). It is in this exploitation role, however, that science parks can be seen to have a specific role in conjunction with universities.

2.3.4 The key role of the science park in exploiting innovation

The concept of science parks can be traced back to the 1950s when the Stanford Science Park was founded by Stanford University in California. Science parks boomed throughout Europe during the 1980s and 1990s (Bakouros, Mardas, & Varsakelis, 2002; Storey & Tether, 1998), and in Asian countries in the mid-1980s (Phan et al., 2005). Simultaneously, a number of other types of property-based developments with similar roles to science parks were developed, particularly technology parks, technopoles, innovation parks and research parks (Sofouli & Vonortas, 2007). According to Link and Scott (2003) each can be distinguished as follows: (i) research parks are characterised by tenants that are mostly engaged in basic and applied research, (ii) science parks (including technology parks) are characterised by tenants that are more heavily engaged in applied R&D, and (iii) technology or innovation parks in particular often house new start-up companies and incubation facilities. Commercial or industrial parks can also be distinguished from science parks on the basis of their tenants, who apply value-adding activities to existing R&D-based products or production-orientated activities as opposed to conducting R&D activities (Cheng, van Oort, Geertman, & Hooimeijer, 2014; Huang, Yu, & Seetoo, 2012; Link & Scott, 2003b). Also, while Technopoles and the multimedia super corridor often share similar goals to science parks (Boucke, Cantner, & Hanusch, 1994; Chordá, 1996; Ramasamy, Chakrabarty, & Cheah, 2004), they differ in often being created by government and are much larger in physical scale (Chordá, 1996; Ramasamy et al., 2004).

Given the above discussion, however, unsurprisingly there is no uniformly accepted definition for the science park (Cheng et al., 2014; Fukugawa, 2006; Hansson, Husted, & Vestergaard, 2005; Lindelöf & Löfsten, 2006; Link & Link, 2003; Link & Scott, 2003b; Löfsten & Lindelöf, 2001, 2002, 2003). Phan et al. (2005) also demonstrate that no general theory for the science park exists due to the origins and consequences of the parks being varied depending on their geographic locations, political and social context, as well as economic systems. However, Quintas et al. (1992) define science parks, at their simplest, in terms of property developments to support commercial research activity.

While universities are often instrumental in founding science parks, this activity is more concentrated in some countries and universities than others. In the UK, the Cambridge, Heriot-Watt and Surrey Science Parks were each set up by universities (Westhead & Batstone, 1998), while in Sweden, universities have worked alongside local authorities and development agencies to encourage the formation of heterogeneous groups of parks (Lindelöf & Löfsten, 2006). By contrast, the Kista science park in Sweden evolved from a cluster centred on Ericsson into the Kista Science City and did not need a university as a precursor to its establishment (Cabral, 2005). While in Japan, the 'centre facility' approach involves a public–private organisation taking on the role of the university to offer facilities and services to entrepreneurs (Bass, 1998).

Ng, Appel-Meulenbroek, Cloodt and Arentze (2019) indicate that the ownership of science parks are various, including public and/or private science park owners. By comparing private science parks and university science parks, private science parks (e.g., the Kilometro Rosso Science Park in Italy) are managed by a private company and the parks are aimed at promoting networks among partnerships as well as enhancing the interactions between on-park and off-park firms (Corsaro & Cantù, 2015), while the university science park offers the entrepreneur access to the intellectual resources of academic staff and advice on establishing a new venture (Wright, Liu, Buck, & Filatotchev, 2008). In terms of drawbacks, some private research parks limit the number of on-park firms (Layson, Leyden, & Neufeld, 2008), while the university science parks may offer less access to commercially oriented expertise and contacts (Wright et al., 2008). Broadly, in sum, a science park is typically characterised by: (1) having links with academic institutions, (2) supporting the start-up and incubation of technology-based firms, (3) fostering the transfer of technology and business knowledge, (4) property-based initiatives, and (5) their sustainable nature (Durão, Sarmento, Varela, & Maltez, 2005).

As science parks have links with academic institutions, they can contribute to both on-park firms and to the university that the park is affiliated with. According to Albahari, Pérez-Canto, Barge-Gil and Modrego (2017), they analysed how the level of involvement of a university in the science park affects the innovation outputs of its tenants and their links with the university. Their results show that higher involvement of a university positively affects the number of patent applications but negatively affects on-park firms' innovation sales. Universities may possibly receive income, together with technology transfer, as well as have the opportunity for their personnel and students to interact at an applied level with technology-based organisations, while science parks may help universities to build and improve their reputation (Helmers, 2019; Link & Scott, 2017); for example, the case of the Riyadh Techno Valley (RTV) project, which was started at the King Saud University with the aim to *'accelerate and promote knowledge spillovers'* from the university (Alshumaimri, Aldridge, & Audretsch, 2017). All of these examples highlight the science park and university contributions to tenants from the links between the science park and the academic institution.

One consequent approach to conceptualising the science park's role, suggested by several authors, is based on the 'linear model' (Massey & Wield, 2006; Quintas et al., 1992; Westhead, 1997). This starts from basic research, through to applied research activities through to the development of new products, testing of prototypes, as well as products that can be commercialised and then diffused. The science park can therefore be seen to play the role of a catalytic incubator environment for the transformation of pure research into production. Authors such as Feldman (2007) highlight the role of science parks in innovation exploitation (Huang et al. (2012), potentially generating smaller (Staudt, Bock, & Muhlemeyer; 1994) or larger (Storey & Strange, 1992) benefits in terms of employment growth as well as benefits in terms of better sales and sales growth performance (Gwebu, Sohl, & Wang, 2019). More specifically, small and medium-sized enterprises (SMEs) have been identified as regional growth engines (Cheng et al., 2014), creating wealth and high-value job opportunities through technology-based R&D (Chang, Lee, Lin, & Hu, 2010).

Science parks offer a social environment where proximity between firms supports key information transfer for the development of innovation (Fernández-Alles, Camelo-Ordaz, & Franco-Leal, 2014). Within science parks, the proximity of firms' clustering can enhance the interaction between personnel and extend networking to support the development of innovation, which can be seen in the case of the Hsinchu Science-Based Industrial Park and

Tainan Science-Based Industrial Park (Hu, 2008). The connection between science parks and actors in international countries also helps to form and exchange knowledge in specialised industries. Affirmed by Yang, Hsu and Ching (2009), Hsinchu Science Park set up a strong connection with Silicon Valley and shaped the semi-conductor industrial cluster in northern Taiwan; in addition, the Tainan Science Park transferred the thin-film transistor-liquid crystal display technology from Japan and shaped another high-technology industrial cluster in southern Taiwan. In addition, science parks can be used by government to promote the specialised industry of its local area. For example, the regional government of Lombardy, Italy, promoted initiatives aiming to be the leader for southern Europe, emphasising biotechnologies in the agro-food industry through Parco Tecnologico Padano in Lodi, which specialised in biotechnologies (Bosco, 2007). Also, the six high-tech industries – comprising the computer, semiconductor, communications, photo-electronics, precision equipment and biotech industries – were developed in the Hsinchu Science Park (Chen, Wu, & Lin, 2006).

The preceding discussions reveal the role of science parks in supporting the RIS. Science parks utilise the physical and network infrastructure created through the RIS, alongside their relationships with the universities that support them, to facilitate flows of commercialisable knowledge into new firms created on the science park itself to produce innovation exploitation outcomes. Therefore, science parks are defined as intermediate structures that are established around the university, for example IDEON (Angelakis & Galanakis, 2017), or brokerage institutions that can attract firms and other organisations for cooperation (Almeida, Figueiredo, & Silva, 2011), innovation support infrastructure (Diaz-Puente, Cazorla, & de los Rios, 2009; Doloreux & Dionne, 2008) or facilitators of inter-organisational relationships (Pilar Latorre, Hermoso, & Rubio, 2017).

Lenger (2008) found that in technoparks (or science parks) and university–industry joint research centres, universities, acting as the key actors, made a significant contribution to the RIS. However, the roles and interactions of science parks, as well as a number of other parks, are different in each specific RIS. For instance, Huang and Fernández-Maldonado (2016) indicate that each science park in the Eindhoven city region focuses only on one field of R&D and acts as the centre of the regional economy, facilitating the clustering of relevant industries. One science park in Beauce, Canada, also supported the technological strengths, highlighting the 'institutional thinness' which is characteristic of peripheral regions (Doloreux, 2004). Additionally, Gebauer, Nam and Parsche (2005) have demonstrated that the roles and characteristics of innovation centres in Germany are smaller than in Silicon Valley. Even though the roles, relationships and characteristics of each science park vary within the specific RIS, Gkypali, Kokkinos, Bouras and Tsekouras (2016, p. 327) suggest that the science park *'needs to reorientate its position within the corresponding RIS'* and:

> *needs to set its priorities in supporting STI [science, technology and innovation] policies based on youth entrepreneurship, promoting the commercialization of the significant research output of the higher education institutions of the region and developing relationships among the high-tech startups and the incumbent firms of the region*.

The researcher utilises the linear approach (e.g., Massey & Wield, 1992; Quintas et al., 1992; Westhead, 1997), as a simplifying framework to structure the sections that follow. The preceding discussion also highlights, however, that while RISs, universities and science parks have different roles in the innovation process, there are also clear, strongly overlapping relationships through which these roles are displayed.

2.3.5 The university–RIS relationship and its focus on basic research for dissemination

Rip (2002) emphasises how universities have evolved to more closely support both RIS and strategic science, which can also be seen as constituting basic research. Rip's (2002) case study analysis of the University of Twente in the Netherlands found:

> *The University of Twente has a strong regional orientation, but that its spin-offs strengthen the economy, not necessarily the regional innovation system. It is also prominent (in selected areas) at the international research frontier. Promising options are a key feature of strategic science, but their 'promise' most often is not*

> *defined in regional terms, but in relation to a global scientific and technological frontier.* (p. 129)

Several other studies also suggest weaknesses in universities' abilities to enhance the RIS. Gunasekara (2006) undertook an analysis of three Australian universities, utilising a conceptual framework based on the triple helix model and literature on university engagement and innovation systems. This research found universities to be weak in their willingness and capability to act like industry, generating poor commercial benefits. In Daedeok Innopolis, universities were also found to have strong links with public research institutions, but weaker links were demonstrated between firms and universities (Yoon, Yun, Lee, & Phillips, 2015). Hence, universities are often perceived to be relatively weak in this aspect as a result of a greater focus on education over those activities of most relevance within many RISs, specifically R&D activities which are closer to market (as opposed to basic research). It was these weaknesses that led Chung (2002) to suggest the need for policies supportive of innovation, such as the recruitment of experienced professors and collaboration between academics and researchers in research centres.

2.3.6 The RIS–university–science park relationship and its focus on product development

Many governments globally have used science parks to stimulate the regional economy by fostering the growth of NTBFs and science-based industry. For example, the Government of Taiwan established science parks, officially defined as offshore economic zones, with complementary business services and financial incentives provided to high-technology manufacturers (Tsai, Wen, & Chen, 2007). To date, however, there have been only a limited number of studies focusing on science parks while also incorporating the RIS. Specifically, Gkypali et al. (2016), Hommen, Doloreux, and Larsson (2006), Jonsson (2002), Yoon et al. (2015), Zhang (2015), and Zhu and Tann (2005) were found to constitute the small minority of papers specifically emphasising the study of the science park while also discussing its relationship with the RIS. Unsurprisingly, the majority (four of these six papers) also discussed the role of the university within this context. The limited number of papers identified within the university category again highlights the lack of studies in this specific area.

Taking a broader perspective, for universities to become more effective in their RIS the knowledge they supply must fit with the needs of their region's firms and raise future interest in their services through product development (e.g., Tödtling & Kaufmann, 2002). Consequently, many universities have set up science parks and incubation centres to help firms overcome obstacles in the innovation process and strengthen university–industry interactions (Asheim & Coenen, 2006; Gunasekara, 2006; Malairaja & Zawdie, 2008; Vedovello, 2002). These are supported by Technology Transfer Offices (TTOs), which require close proximity and systemic links between university and industry.

Science parks are also viewed as policy instruments for encouraging regional development, innovation and the setting up of new firms through networks between HEIs and industry (Hansson et al., 2005; Hu, Lin, & Chang, 2005). In particular, policymakers see science parks as 'meta-organisations', important in the task of getting SMEs to participate more closely in knowledge creation with universities and research institutions (Giaretta, 2013). This underlines the importance of the science park in terms of promoting links with the university, with the aim of making contributions to the regional economy. Indeed, Zhu and Tann (2005) analysed the Zhongguancun science park and investigated the linkages and the knowledge flows between several actors of Zhongguancun science park, viewing the park effectively as a RIS in itself, a social system of clusters interacting systematically through linkages and flows to enhance the learning and competitive capabilities of the region. In this context, science parks form an important component in the broader government-supported RIS. They are seen as a tool of regional development policy through transferring university-generated public knowledge to NTBFs through product development within regional contexts (Fukugawa, 2006; Vedovello, 2002).

2.3.7 The science park–university relationship and its focus on applied research

There is much research focused on the role that the science park plays in bridging the gap between university and industry (Bakouros et al., 2002; Malairaja & Zawdie, 2008;

Phillimore, 1999; Quintas et al., 1992; Vedovello, 1997), though there is much less focus in the literature on the developing-economy context when compared to more developed-economy examples. As outlined previously, science parks are conceived as a mechanism to help link research results from universities more closely to the market and stimulate technological spillovers (Löfsten & Lindelöf, 2005; Siegel, Westhead, & Wright, 2003a). Consequently, for universities, the main aim of establishing science parks is to exploit their R&D results and research ideas, and secure funding for future research (Hansson et al., 2005).

Proximity between knowledge creators in the university and firms in the science park can also be seen in a range of geographical contexts to be important to the attractiveness and growth of science parks (Guy, 1996; Ma, 1998; Siegel, Westhead, & Wright, 2003b; Pálma, 2004; Fikirkoca & Saritas, 2012; Link & Scott, 2003a; Ratinho & Henriques, 2010). These links can be divided into forms: formal (e.g., licensing and co-operative alliances) and informal (e.g., personal relations, business partners, family ties and the mobilisation of personnel) (Bakouros et al., 2002; Dettwiler, Lindelöf, & Löfsten, 2006; Lindelöf & Löfsten, 2004; Westhead & Batstone, 1999).

The advantages of close linkages identified within the literature include: access to experts providing improved performance (Dierdonck, Debackere, & Rappa, 1991; Lindelöf & Löfsten, 2004; Vedovello, 1997), providing the latest knowledge (Markman, Phan, Balkin, & Gianiodis, 2005; McAdam & McAdam, 2008), encouraging R&D activities amongst firms (Siegel, Westhead, & Wright, 2003a), and maintaining and supporting industrial innovation (Hu, 2008). In addition to the receipt of academic knowledge, a number of other factors have been found to influence firm decisions to locate in science parks. For example, Westhead and Batstone (1998) found that many NTBFs decide to establish or relocate into science parks because of the perceived prestige and image enhancement associated with being linked to HEI research centres. A case study of the Tsinghua University (THU) Science Park also revealed the significance to firms of reputational benefits from being located in the park (Motohashi, 2013). The links between academia and industry within science parks are therefore complex. For universities, however, proximity to a science park can also fundamentally shift their mission from basic to applied research (Link & Scott, 2003b).

2.4 The conceptual framework

2.4.1 The two-dimensional matrix

The analysed literature identifies the 'university' as sitting at the centre of the RIS–university–science park nexus. The university plays an important, specific role in its own right as a knowledge broker. It also further contributes through its relationships with the RIS and science park, as these relate to a university's potential basic research and dissemination of and applied research activities. The university's focus therefore changes depending on these relationships. Specifically, in addition to directly brokering knowledge, the university plays supporting roles with regards to resourcing and innovation commercialisation.

The two-dimensional matrix demonstrating the roles of university and relationships between the RIS–university, RIS–university–science park and university–science park was developed as the conceptual framework of this thesis. The matrix was built upon two mainstream literature areas ('science parks' and 'RIS incorporating science parks'). The roles of the university and the examples indicated in the matrix were gleaned from a systemic literature review approach, especially from empirical case studies of various research in the areas in which universities were relevant. Hence, the role of the university and the relationships among actors are the two main dimensions that the matrix focuses on (see Figure 2.1), where SP refers to science park.

Relationships between actors

Roles of University	RIS actors + University	RIS actors + University + SP	University + SP
	Knowledge co-creation (Basic Research)	Conduit (Product Development)	Inter-organisational relations (Applied Research)
Resource Sharing	(Cell 1) Provision of information	(Cell 2) Providing the channels of communication	(Cell 3) Provision of infrastructure
Brokerage Role	(Cell 4) Building regional networking	(Cell 5) Research collaboration (R&D activities between actors)	(Cell 6) Knowledge intermediaries
Exploitation and Commercialisation	(Cell 7) Economic development and wealth creation	(Cell 8) - Development of Commercialisation (e.g. licensing activities, patents) - Promoting technological change	(Cell 9) - Start-ups creation (incubator) - Promoting the commercialization of research results

FIGURE 2.1 THE TWO-DIMENSIONAL MATRIX PRESENTING THE ROLES AND RELATIONSHIPS OF THE UNIVERSITY

The matrix demonstrates the relationships between actors, which can be divided into the relations between university–RIS actors, university–RIS–science park actors and university–science park actors. Firstly, the interaction between university–RIS actors could be termed as 'knowledge co-creation' because universities have the main role of producing knowledge and then disseminating it to the other actors in the RIS. Moreover, universities usually cooperate with regional firms to undertake collaborative projects by conducting basic research and creating new knowledge. Secondly, the relations between the university, RIS and science park actors could be viewed as the 'conduit'. This is because the science park, when combined in this type of relationship, can foster linkages between the university and the other RIS actors, enhancing product development and commercialising these products. The last relationship occurs between the university and science park actors, which could be defined as 'inter-organisational relations', and has many subtypes of links. The more linkages, the more organisations are involved, including the government, researchers, firms, policymakers, business ventures, and so on. What is more, the university and science park can further expand their basic knowledge by undertaking applied research.

Utilising the linear model approach, the literature in the tables below (see Tables 2.7, 2.8 and 2.9) can be initially conceptualised as an innovation 'pipeline', reflecting the three different roles (including resource sharing, brokerage role, and exploitation and commercialisation) performed by the university both individually and through its relationships with the RIS and science park. Details of the empirical evidence from the systematic literature review is summarised in Tables 2.7, 2.8 and 2.9, exploring more fully: (1) the parties involved and the activities associated with specific inter-relationships; and (2) the specific importance of the university in terms of resource sharing, brokerage, and exploitation/commercialisation.

TABLE 2.7: A SYNTHESIS OF THE EMPIRICAL WORK CONNECTED TO THE ROLES OF THE UNIVERSITY IN THE RIS-UNIVERSITY–SCIENCE PARK NEXUS: RESOURCE SHARING

Resource Sharing Roles	Key References	Specific Roles of Universities Identified
Cell 1 Providing Information (RIS actors + University)	Boucke, Cantner, & Hanusch (1994)	Running regional science centres aimed at coordinating cooperation and information transfer between the HEI and local firms.
	Looy, Debackere, & Andries (2003)	Setting up a TTO, through which the staff of the TTO was promoted information exchange through an industrial collaborative programme.
	Zou & Zhao (2013)	Having intense information exchange through academic, business and personal networks.
Cell 2 Providing Communication Channels (RIS actors + University + Science park)	Looy, Debackere, & Andries (2003)	Creating Leuven.Inc by KU Leuven R&D (TTO) and IMEC (the Inter-university Center for Micro-Electronics) to stimulate the exchange of ideas and the creation of networks.
	Watkins-Mathys & Foster (2006)	Casual social exchanges between researchers, entrepreneurs and officials within and outside the Chinese science, technology and innovation parks (STIPs), as well as interactions in the community around the parks.
	Zou & Zhao (2013)	The enterprises in TusPark that operated with THU can cooperate and communicate with Tsinghua alumni network.
Cell 3 Providing Infrastructure (University + Science park)	Bruton (1998)	Providing space.
	Westhead & Batstone (1998)	Providing access to facilities of the HEI/centre of research.
	Kihlgren (2003)	Providing the building.
	Bigliardi, Dormio, Nosella, & Petroni (2006)	Providing access to the available tools.
	Hommen, Doloreux, & Larsson (2006)	Providing R&D infrastructure.
	Sofouli & Vonortas (2007)	Providing access to the laboratories.

2.4.1.1 Resource sharing roles

'Resource sharing' in this thesis includes offering, facilitating, and supporting research results, data and information that the university produces for others actors within the RIS. From the matrix, resource sharing roles can be divided into cells 1, 2 and 3, which demonstrate the different roles of the university under the various relationships (see Table 2.7).

CELL 1: PROVISION OF INFORMATION

In cell 1, the role of the university is defined as 'providing information', stressing the main role of the university is to exchange information with firms and other RIS actors. To perform this role, some universities set up science parks/ science centres/ TTOs to facilitate information transfer with actors in the region (e.g. Looy et al., 2003).

In this function the University itself produces knowledge, has connections with firms to create and generate new knowledge by conducting research, and shares knowledge or information with firms through specific courses/training (Hommen et al., 2006) or through academic, business, and personal network (e.g. Zou & Zhao, 2013).

CELL 2: PROVIDING THE COMMUNICATION CHANNELS

In its relationship between the science park and RIS, the university then provides channels of communication. Here the university can play a key role in creating networks, as well as helping to ensure and optimise communication and cooperation between the key actors (Jonsson, 2002; Löfsten & Lindelöf, 2005). This can play a key role in the transfer of tacit knowledge through varied networks of actors (e.g., Looy et al., 2003; Zou & Zhao, 2013). This occurs through conferences, meetings, exhibitions, social networks, as well as firms' interactions with students, staff and researchers who have the specialised skills consistent with industry needs.

CELL 3: PROVIDING INFRASTRUCTURE

The final resource sharing role highlights the sharing of infrastructure between the university and science park. The university allows on-park firms to access their facilities. Some universities invest in land and building (Quintas et al., 1992) or provide office facilities

(McAdam & McAdam, 2008), space, R&D infrastructure, available tools and laboratory equipment to support the science park (e.g., Bruton, 1998; Sofouli & Vonortas, 2007).

2.4.1.2 Brokerage roles

The central university 'brokerage role' encompasses the university acting as a 'seedbed', creating conditions to promote innovation as an incubator, facilitating the transfer of knowledge, encouraging spin-offs and stimulating the production of innovation (Felsenstein, 1994). From the matrix, brokerage roles can be divided into cells 4, 5 and 6, which demonstrate the different roles of the university under the various relationships (see Table 2.8).

TABLE 2.8: A SYNTHESIS OF THE EMPIRICAL WORK CONNECTED TO THE ROLES OF THE UNIVERSITY IN THE RIS-UNIVERSITY–SCIENCE PARK NEXUS: BROKERING

Brokering Roles	Key References	Specific Example Roles of Universities Identified
Cell 4 Building Regional Networking (RIS actors + University)	Storey & Strange (1998)	Providing a formal programme for distribution of knowledge from the university's research directly to firms.
	Hommen, Doloreux, & Larsson (2006)	Providing education and training, supporting the spin-off of academic research into a network of industrial firms and other organisations.
	Yoon, Yun, Lee, & Phillips (2015)	Making a transition toward the entrepreneurial university by forming a consortium with other would-be entrepreneurial universities abroad and collaborating with foreign universities and attracting international students to the region.
	Lew et al (2018)	Developing internship programmes.
Cell 5 Research Collaboration (RIS actors + University + Science park)	Jonsson (2002)	Having collaborations between on-park firms, individual researchers or teams of researchers at universities and hospital clinics.
	Bigliardi, Dormio, Nosella, & Petroni (2006)	Providing a programme of specialist seminars and a database that specifies competences in the innovation and technology transfer programme of the science park to companies.
	Watkins-Mathys & Foster (2006)	Having commercial contracts for R&D product development (between university incubators and hi-tech STIP firms) and offering financial loans to start-up companies to work on technology product development.
	Sofouli & Vonortas (2007)	Having links with industry and research centres in joint research projects.
	Malairaja & Zawdie (2008)	Having joint collaborative research with a science park and off-park firms.
Cell 6 Knowledge Intermediaries (University + Science park)	Jonsson (2002)	Having social contact networks in which university knowledge is channelled to on-park firms.
	Lai & Shyu (2005)	Providing science parks with high-quality human resources and on-the-job training.
	Bigliardi, Dormio, Nosella, & Petroni (2006)	Consulting and providing access to online databases.
		Collaborating with science parks to provide quality and certification programmes offering integrated services, such as consulting, testing, certifying the quality required for commercialising products, etc.

CELL 4: BUILDING REGIONAL NETWORKS

The first brokerage function performed by the university focuses on building regional networks with and between the other actors within the RIS. This could be, for example, through labour mobility, formal programme, training and forming a consortium (e.g. Storey & Strange, 1998, Yoon, Yun, Lee, & Phillips, 2015).

In addition, mobility could be considered as a vehicle of intangible knowledge transfer. For instance, the mobility of engineers and scientists between large firms, start-ups and service organisations could transfer both tangible and intangible knowledge, creating a more dynamic local system (Ramirez, Li, & Chen, 2013). Hence, some universities support the mobility of academic personnel to transfer knowledge as a way to build regional networking.

CELL 5: RESEARCH COLLABORATION

In the university's second brokering role it supports interactions to create and promote innovation between the university, science park and other actors in the RIS. Research collaborations between these actors are considered crucial in this and, across a number of industries, R&D collaboration between them is highly valued (Kramer et al., 2011). For firms and the RIS, the university's investments in R&D provide benefits that can contribute to their innovation processes (Barra & Zotti, 2018), while the university benefits from R&D collaboration through additional income and experience of firms' real-life problems (Harper & Georghiou, 2005).

This thesis defines research collaboration in this type of role-playing by the university as not only undertaking R&D collaborative projects but also including other forms of collaboration, such as commercial contracts for product development, offering loans granted by the university, encouraging cross-licensing, and so on.

CELL 6: KNOWLEDGE INTERMEDIARIES

Finally, within the science park itself, the university can then act as a 'knowledge intermediary'. In this role, the university can search for and absorb local and non-local knowledge and then transmit this knowledge to the science park to improve firms' innovative capability (e.g., Díez-Vial & Montoro-Sánchez, 2016, Macdonald, 2016). This role is increasingly promoted by government to encourage technology transfer and regional development due to it supporting the geographical clustering of firms (Tan, 2006). Some universities share social contact networks, provide training/consulting as well as offer specialist programmes to on-park firms in order to transfer knowledge.

2.4.1.3 Exploitation and commercialisation

The final role, 'exploitation and commercialisation', involves activities making use of and benefiting from these resources and brokering activities to assist economic development through innovative products. These are exploited through commercialisation processes within the science park to produce commercial returns, which further strengthens the businesses utilising them and the RISs in which they sit. From the matrix, exploitation and commercialisation can be divided into cells 7, 8 and 9, which demonstrated the different roles of the university under the various relationships (see Table 2.9).

TABLE 2.9: A SYNTHESIS OF THE EMPIRICAL WORK CONNECTED TO THE ROLES OF THE UNIVERSITY IN THE RIS-UNIVERSITY–SCIENCE PARK NEXUS: EXPLOITATION AND COMMERCIALISATION

Exploitation and Commercialisation Roles	**Key References**	**Specific Roles of Universities Identified**
Cell 7 **Economic Development and Wealth Creation** **(RIS actors + University)**	Gunasekara (2006)	Development of a technology precinct and innovation campus.
	Yoon et al. (2015)	Having incubated ideas, educated entrepreneurs and fostered breakthrough technologies.
		Establishing technology holding companies.
Cell 8 **Development of Commercialisation (e.g. Licensing Activities, Patents), Promoting Technological Change** **(RIS actors + University + Science park)**	Hommen, Doloreux, & Larsson (2006)	Having a university holding company located in the science park, which commercialises research and ideas, serves as 'a conduit between academia and industry, providing university faculty and students establishing new businesses with referrals to key services related to commercialisation of research results, such as IP management, access to seed capital, etc.
	Xie et al. (2018)	Intensive interactions with government, enterprises, universities, and agencies have led Donghu High-Tech Zone to become an industrial ecosystem. Parties such as universities and research institutes, venture capital institutions, and business incubators provide a variety of input factors for technology start-ups through the transfer of IP rights or cooperative development.
	Guy (1996)	Linking with the science park and other universities, aimed to help and keep companies at the forefront of technological advances by providing a resource for technical research and project-based support.
Cell 9 **Creating Start-ups (Incubator), Promoting the Commercialisation of Research Results** **(University + Science park)**	Pálmai (2004)	University teachers move their enterprises to the site of the innovation park, establish their own real enterprises and convert the virtual company into a legal entity.
		An enterprise starts its business operation directly with the university and relies on the business services of the innovation park during its operation.
	Shearmur & Doloreux (2000);	Creating incubator programs to expand boundary services by aligning with the science park
	Feldman (2007)	Support for entrepreneurship policies and spin-offs helped promote the science park and faculty members' participation in the science park.
	Zou & Zhao (2013)	One of the initial missions of the university-established science park was *'Promoting the commercialization of research results'* .

CELL 7: ECONOMIC DEVELOPMENT AND WEALTH CREATION

In terms of RIS–university relationships, the role of the university also includes directly increasing local economic development (e.g., Ku, Liau, & Hsing, 2005). This is achieved through vehicles such as technology companies and innovation campuses.

The university acts as an economic magnet, attracting investment, entrepreneurs and talent to a region (Macdonald, 2016). Consequently, it can encourage local economic development. To perform this role, some universities set up technology precinct/ innovation campus/ technology holding companies and strengthen the links with key actors in the region.

CELL 8: DEVELOPMENT OF COMMERCIALISATION AND PROMOTING TECHNOLOGICAL CHANGE

The second exploitation and commercialisation role of the university focuses on its simultaneous relationships with the science park and RIS actors (e.g., Looy et al., 2003). Given that the primary purpose of firms in a science park is to launch new products and develop markets (Löfsten & Lindelöf, 2003), the university's role in commercialisation is essential and often supported by specific government policies (Mian, Lamine, & Fayolle, 2016). This effort is focused through the development of vehicles for commercialisation (e.g., licensing, patents), as well as more broadly promoting technological change, for example, by critically reviewing and then systematising the technical knowledge accumulated (Hu, 2008).

CELL 9: CREATING START-UPS AND PROMOTING THE COMMERCIALISATION OF RESEARCH RESULTS

In the final exploitation and commercialisation role, universities increasingly participate directly in the commercialisation of knowledge via licensing activities and spin-off firms (Looy et al., 2003). Sofouli and Vonortas (2007) support this notion in their case study of science and technology parks and business incubators of Greece; especially in the first policy wave (the 1990s), the government provided funding support for universities and other public research institutes to establish parks in order to exploit R&D results. Spin-off firms are also seen as crucial in the development of university–industry relationships and as a tool for the valorisation of research results (Salvador, 2011). Indeed, Hansson et al.

(2005) further claim that universities expect science parks to help them commercialise their research ideas and secure funding for further research.

According to Löfsten and Lindelöf (2001), an incubator can be defined as an organization, providing resources that enhance new small business creation and supporting corporate spin-offs, particularly NTBFs. Combined with the operation of the science park, business incubators can expand the boundaries of their services (Wonglimpiyarat, 2010). Many science parks, thus, have accommodated incubator programmes in order to encourage NTBFs (Chan & Lau, 2005). Some science parks also receive support from universities to establish incubator programmes.

2.5 Conclusions, research gaps and research questions

By conducting the systematic literature review, the roles of the university in the RIS–university–science park nexus were revealed. With a lack of studies identifying the roles played by the university specifically in relation to RIS actors or science parks and only a few studies (e.g., Hommen et al., 2006; Jonsson, 2002; Zhang, 2015; Zhu & Tann, 2005) linking the literature on science parks and RIS together, this highlighted the gap in the literature, leading to the first research question of this thesis: *'What are the specific roles of the university and relationships between the RIS, university and science park actors?'* In order to fill the gap and answer the first research question, the two-dimensional matrix – or the conceptual framework – of this thesis was built, illustrating the roles of the university and its relationships between the RIS–university, RIS–university–science park, and university–science park actors.

Some research gaps have appeared in the literature on science parks. For example, Lecluyse, Knockaert and Spithoven (2019, p. 574) identified a gap from their review: '*more research is needed in order to understand the relationship between the region that the science park is located and the contribution the science park can provide*'. Additionally, the impact of regional policies in the creation and development of science parks should be analysed, as suggested by Mora-Valentín, Ortiz-de-Urbina-Criado and Nájera-Sánchez

(2018). All of these examples hence support the review of Hobbs, Link and Scott (2017, p. 963), which indicate that '*although there has been substantial growth in the literature, the science and technology park literature is, to repeat the National Research Council's term, still "embryonic"*'. Conducting the systematic literature review revealed that no general theory of the science park exists due to the origins of the parks being different depending on a range of factors and the context of the country. This emphasised the need to identify the roles and relationships between the science park, university and involved actors in the specific national or regional context.

More specifically, the systematic literature review of this thesis disclosed a strong imbalance in the geographic distribution of prior studies, with the majority having been conducted in developed countries and core regions. Thus, more research should be conducted in developing countries and peripheral regions. Because of this research gap, and due to this thesis being focused on the roles and relationships of the university, the second research question, *'What are the specific roles of the university and relationships between the RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?'* was constructed to identify the specific roles of the university in the RIS–university–science park nexus within the specific peripheral region developing-economy context.

By conducting the systematic literature review, a clear gap was found with respect to the roles of the university and its relationships with the other actors in the actual innovation process. Specifically, only two papers from the systematic literature review (i.e., Hommen et al., 2006; Zhu & Tann, 2007) address this issue in-depth, with most papers just mentioning or referring to this issue but without any in-depth analysis. Combined with the specific gap in the peripheral economy developing-economy context, more research is required to identify the activities between RIS–university–science park actors and to understand how the university contributes to on-park firms within the specific peripheral RISs of developing countries. This highlights RQ3a and RQ3b of this thesis: *'What are the roles of the university in its relationships between the RIS, university and science park actors in innovation projects conducted with on-park firms?'* and *'How does the university* *contribute to the innovation activities of on-park firms in the context of a peripheral developing economy?'*

More broadly, although universities and science parks are found to be crucial components in the RIS, there are only a limited number of previous studies (e.g., Jonsson, 2002; Yoon et al., 2015; Zhu & Tann, 2005) that illustrate how the role of the science park and the interactions with the university could help develop the RIS. Combined with the specific gap in the peripheral region developing-economy context, further research is therefore needed to illustrate how the university and science park contribute to the development of a peripheral RIS in a developing-economy country. Consequently, the last research question (RQ4) of this thesis was established as: *'How do the university and science park contribute to the development of a peripheral RIS in a developing economy?'*

Summing up, the systematic literature review identifies the importance of placing the research in context, which requires a detailed review of the specific context used in this thesis. The next chapter therefore undertakes an in-depth review of the context of the peripheral RIS (including the roles and relationships of universities and science parks) as well as a specific RIS in Northern Thailand.

Chapter 3: Research Context

3.1 Introduction

This chapter provides an overview of the research context for the study. It begins with a review of the RISs of peripheral regions, the roles of universities and science parks in the RISs of peripheral regions, as well as RISs in developing countries. The chapter then concludes with details of an RIS in the Thai context, focusing on the NT-RIS. Therefore, this chapter provides the background information that underpins this thesis.

The research questions of this thesis were constructed from the systematic literature review approach outlined in the previous chapter. Reviewing the specific research context in this chapter will, however, assist in the evaluation of the research material related to the last research question: 'How do the university and science park contribute to the development of a peripheral RIS in a developing-economy context?' By identifying the existing literature for the specific research context, including the empirical evidence available for Northern Thailand, this will aid discussion of the research results. This chapter therefore identifies the general characteristics of peripheral RISs generally and supportive elements in Thailand specifically, as well as illustrating the interactive innovation processes among actors in the NT-RIS.

3.2 RISs of peripheral regions

According to Autio (1998), an RIS is comprised of two subsystems: knowledge generation and knowledge exploitation. The knowledge-generation subsystem comprises public and private research laboratories, universities and colleges, technology transfer agencies, science parks, innovation centres, polytechnics, vocational training organisations, and so on, while the regional exploitation subsystem consists of companies, their clients, suppliers, competitors and cooperation partners. Both these subsystems are embedded in a regional socioeconomic territory. If these two subsystems are involved in the processes of interactive learning and linked to global, national and other regional systems, it could be defined as a well-functioning RIS (Asheim, Moodysson, & Tödtling, 2011).

With respect to Cooke and Morgan (1998, p. 64), regions are viewed as *'territory smaller than their state possessing significant supra-local governance capacity and cohesiveness differentiating them from their state and other regions'.* Hence, the concept of an RIS has been emphasised in regions because innovation systems are more easily observed at the regional level (Andersson & Karlsson, 2006). Moreover, regions offer specific environmental conditions and opportunities for interactions that can either foster or hinder co-operation among actors (Fagerberg, 2003).

In various regions, RISs have differed depending on individual actors, innovation processes among actors and industrial specialisation. For example, regions in the European Union (EU) context with per capita gross domestic product (GDP) below 75% of the EU average can be defined as peripheral regions, and are seen as being comparatively economically backward regions (Mudambi & Santangelo, 2016). Komninaki (2015) asserts that there are relatively limited interactions between actors, especially in peripheral regions. Prior studies demonstrate that RISs of peripheral regions are often weak due to innovation activities focusing on incremental and process innovation, networks among actors being limited, and organisational 'thinness' (Asheim, Moodysson, et al., 2011; Isaksen, 2001; Franz Tödtling & Trippl, 2005). This therefore highlights the general characteristics and factors hindering innovation capabilities and processes in the RISs of peripheral regions.

First, innovation activities in RISs of peripheral regions are based on incremental and process innovation. As incremental innovations are improvements of existing products and processes, peripheral regions' RISs, therefore, have a lot of firms in less-innovative industries which make little use of R&D in the innovation process (Asheim & Isaksen, 1997). Confirmed by the evidence of Tödtling (1992), firms in Waldviertel, the peripheral rural area of Austria, are small firms and have limited capabilities in R&D, marketing and planning, as well as focus on process innovation.

Secondly, the RISs of peripheral regions are weak due to networks or interactions among actors being restricted. According to Cooke, Roper and Wylie (2003, p. 373), *'Internal R&D offers benefit in terms of knowledge generation and absorption, while innovation networks offer possible advantage in terms of sharing risk, accessing additional technological or human resources and accelerating innovation'.* This highlights that networks are necessary for the RIS to function. Thus, firms usually form clusters and connect with actors in the same region, other regions, as well as internationally in order to retain the flow of learning that supports the generation and diffusion of innovation. Supported by evidence from the case of Beauce in Quebec (Canada), firms relied on external links with metropolitan and international partners due to links within the region being limited (Doloreux, 2003).

Lastly, some peripheral regions are characterised by organisational 'thinness' in which the region may lack relevant local actors, including knowledge and support organisations, or has low levels of support infrastructure and specialised services constituting an RIS (Doloreux & Dionne, 2008). Evidence from the case of Dytiki Ellada in western Greece showed that the low performance of RISs came from weak organisations, insufficient institutions and inadequate infrastructure (Komninaki, 2015).

According to Andersson and Karlsson (2006), innovations are the outcome of an interactive process in which actors from various levels are involved. Most of the research on RISs has focused on system coherence, system boundaries, system dysfunction and failure of well-functioning and successful economies (Asheim, Smith, & Oughton, 2011). Therefore, there is a need to study the system coherence or interactive innovation process among actors in the RISs of peripheral regions, which are less innovative, in order to contribute to the RIS literature. In so doing, the key literature on the specific research context of peripheral RISs is reviewed in this chapter. This can then be used to analyse research data from the Thai case, specifically the context for answering RQ4 which aims to reveal the role of the science park, particularly through interactions with the university, in helping to develop the RIS, particularly in the peripheral region developing-economy context. The details are provided in Table 3.1.

TABLE 3.1: KEY CONTEXT-RELATED COMPARISONS WITH SUPPORTING REFERENCES RELATED TO RQ4

Key areas for comparison	Key supporting references
1) General characteristics of peripheral RISs - innovation activities in peripheral RISs - networks among actors are limited - organisational thinness	Asheim, Moodysson, et al. (2011); Isaksen (2001); Tödtling & Trippl (2005)
2) Comparison between the interactive innovation processes in peripheral RISs from literature and those from the findings of this thesis	Doloreux (2003); Doloreux, Isaksen, Aslesen, & Melançon (2009); Doloreux & Dionne (2008)
3) Comparison between the supportive elements in peripheral RISs from the literature and those from the findings of this thesis - specialist forums and organisation/agency and specialist programmes	Isaksen (2001); Tödtling & Sedlacek (1997); Cooke, Roper, et al. (2003); Asheim & Isaksen (1997); Brown (2016)
4) Comparison between the roles of universities in peripheral RISs from literature and those from the findings of this thesis	García-Aracil & De Lucio (2008), Doloreux & Dionne (2008), Tödtling & Sedlacek (1997), Pavlova & Burenina (2017)
5) Comparison between the NT programme and STeP programmes	Asheim & Isaksen (1997)
6) Comparison between the roles of universities in the RISs of a developing-economy country and those of CMU in the NT-RIS - roles of universities in the RIS of a developing-economy country (China) from literature	Jiao, Zhou, Gao, & Liu (2016); Asheim & Vang (2011); Chen & Kenney (2007)

Extant literature on the peripheral RIS can be classified into three main streams: (i) studies portraying an 'interactive innovation process' among actors, (ii) studies showing 'specialist forums or a specialist organisation/agency' which enhanced the interactive innovation process among actors, and (iii) studies indicating some 'specialist programmes' that encourage the interactive innovation process between actors.

First, prior studies illustrate an 'interactive innovation process' among actors. For instance, Doloreux (2003) indicates that most firms in Beauce, a peripheral region in Quebec, Canada, collaborated with other firms, as well as linked with universities and research institutions outside Beauce to develop innovations. The findings also showed that SMEs in this region are strong in incremental innovation but less so product development. Obvious obstacles in interactive innovation processes include: the lack of labour; the high cost of product and process development; as well as a scarcity of links with universities, research institutions and public organisations located in Beauce. Hence, interactive innovation processes within Beauce are weak, but the degree of interaction with out-of-region partners is strong.

From the case of the aquaculture industry innovation system of Quebec's coastal region, technology transfer organisations have a role solving operational problems. Some institutions support the commercialisation and innovation processes of small firms, though the region has limited extra-regional participation in innovation projects (Doloreux et al., 2009). Therefore, interactive innovation processes in the aquaculture innovation system of this region are limited.

With respect to Doloreux and Dionne (2008), the interactive innovation process of La Pocatière in Canada focuses practical solutions and incremental innovation. In this region, most firms are not engaged in R&D activities but are instead focused on product development. Three types of interaction between private–public organisations are observed in La Pocatière, including:

1) inter-institutional collaborations between local organisations through day-to-day contacts for sharing resources and competencies (e.g., collaborating with the College and Institute of Agri-Food Technology provides access to human and material resources).

2) Co-operation relating to collaborations between firms which aim to design new products, as well as to improve the productivity in the organisation and marketing of new

products. This type of collaboration is developed with partners outside the region, mainly focused on commercial and technological innovation (e.g., Axion and Technologies Lanka collaborate actively with North-American partners to develop electronic parts and communication systems for railway transport).

3) The collaboration between firms and local public organisations which are strong in this region. Mostly, it is the interaction between spin-off firms and parent organisations that offer the environment and conditions favourable for firms to develop, apply, design and market their new products or services.

Secondly, previous studies have explored the RISs of peripheral regions and identified that 'specialist forums or organisations/agencies' enhance the interactive innovation process among actors. From the case of the RIS in Arendal (Norway), a Technology Forum was set up by Ericsson and nine local firms to act as a 'support club' for local industry, a lobby organisation and a 'meeting place' (Isaksen, 2001). The Forum triggered cooperation and a learning culture between local firms and the technical college, as well as launched a local incubator and local venture capital fund that invests in NTBFs.

According to Tödtling and Sedlacek (1997), WIFI (Wissen Ist Für Immer) is the most important intermediary organisation in the Styria RIS (Austria). It provided financial subsidies, supported cooperation and marketing of new products, as well as technology and innovation support and consultancy services focused on education and training. Similarly, the Industrial Research and Technology Unit (IRTU), a public agency, was established in Northern Ireland to strengthen its science and technology base and to improve the links and networks between internal players as well as key international external stakeholders (Cooke, Roper, et al., 2003).

Lastly, prior studies have investigated the interactive innovation process and found 'specialist programmes' were initiated in the RISs of several peripheral regions. From the case of an RIS in Northern Norway, the Innovation and the New Technology Programme for Northern Norway (NT programme) was set up to offer financial support for product and process development in Northern Norwegian companies, as well as to strengthen cooperation between firms and R&D institutions (Asheim & Isaksen, 1997). As for the RIS in Scotland, the 'Interface' programme established a brokerage service to support the building of links between SMEs and universities, helping to create over 1000 SME-University projects in the decade of its operation (Brown, 2016).

This discussion also shows, however, that in addition to the gaps identified in the previous chapter with regards to the literature in the specific RIS–university–science park context, there have also been a limited number of studies exploring the interactive innovation process among actors in peripheral RISs more generally. Table 3.2 identifies the limited number of studies that have discussed these issues, which will be used to focus the discussion of the research conducted in this thesis. This table also shows, however, that these previous studies on RISs in peripheral regions focus on developed economies, again reinforcing a gap in the literature for developing-economy regions.

TABLE 3.2: PRIOR STUDIES PORTRAYED PROCESSES AND SUPPORTIVE ELEMENTS IN PERIPHERAL RISs

Processes and supportive elements in peripheral RIS	Evidence from existing literature	
Interactive Innovation Processes	Beauce (Canada)	- Firms collaborated with others and linked with universities and research institutions that were located 'outside' Beauce to develop innovations. - SMEs are strong in incremental innovation but less developed in product development (Doloreux, 2003).
	Scotland (UK)	- Adria has worked with the IRTU and other regional firms to innovate in clothing (Cooke, Roper, et al., 2003).
	Quebec's coastal region (Canada)	- Technology transfer organisations have the role to 'solve day-to-day operational problems', some institutions supported the commercialisation and innovation processes of small firms; the region has limited organisation from outside participation in innovation (Doloreux et al., 2009).
	La Pocatière (Canada)	- The interactive innovation process is focused on 'solutions and developing incremental innovations rather than being research intensive'. - Firms are not engaged in R&D activities and they focused on product development (Doloreux & Dionne, 2008).
	Styria (Austria)	- Technical University initiated a project to support technology transfer, in which 70 firms were selected to initiate corporations (Tödtling & Sedlacek, 1997).
	La Pocatière (Canada)	- Premier Tech biotechnology initiated a lot of collaborations with research centres in both Europe and South America for data and experiments, as well as exchanging information and improving knowledge in the process of certification (Doloreux & Dionne, 2008).
Specialist Forum and Organisation/ Agency	Arendal (Norway)	- A Technology Forum was set up to act as a 'support club' for local industry, a lobby organisation and a 'meeting place'. - The Forum triggered cooperation and a learning culture between firms and the technical college, as well as launching a local incubator and local venture capital fund that invests in NTBFs (Isaksen, 2001).
	Styria (Austria)	- WIFI, an intermediary organisation, provided financial subsidies, mediation of cooperation, marketing of new products, as well as offered the 'technology and innovation support' or consultancy services focusing on education and training (Tödtling & Sedlacek, 1997).
	Northern Ireland (UK)	- The IRTU was established in Northern Ireland to strengthen its science and technology base and improve links and networks both between internal players and key international external stakeholders (Cooke, Roper, et al., 2003).
Specialist Programmes	Northern Norway (Norway)	- The NT programme was set up to offer financial support for product and process development, as well as to strengthen the cooperation between firms and R&D institutions (Asheim & Isaksen, 1997).
	Scotland (UK)	- The Interface programme was established to facilitate linkages between SMEs and universities (Brown, 2016).

3.3 Roles of universities in the RISs of peripheral regions

In the RIS approach, universities have a fundamental role in interactive innovation processes (Asheim, Smith, et al., 2011; Cooke, 1992). According to Trippl, Sinozic and Lawton Smith (2015), universities are crucial knowledge producers that could link 'the innovation-production spectrum' at the regional level. Hence, transferring knowledge to SMEs is considered a crucial activity of universities in the RIS (Uyarra, 2010).

There have been some studies illustrating the roles of universities and their interaction within the RISs of peripheral regions. For example, García-Aracil and De Lucio (2008) state that universities in the RIS of Valencia (Spain) have interactions with industry through advisory and technical support, education and training personnel, undertaking joint R&D projects, as well as engaging in contract R&D. With respect to Tödtling and Sedlacek (1997), two universities in the RIS of Styria, the Technical University and the Montanuniversität Leoben have interactions with industry by supporting technology transfer and, Montanuniversität Leoben in particular had applied research contracts with firms in the fields of material industry and related products.

From the case of the RIS in La Pocatière, this peripheral region has two main teaching and training institutes, the institute of Agri-Food Technology and La Pocatière College, which encourage applied research and technological transfer (Doloreux & Dionne, 2008). In the RIS of Tomsk (Russia), universities interact with industry through hosting conferences and exhibitions to exchange information, participate in joint and contract research, and cooperate with firms in technology platforms and regional clusters (Pavlova & Burenina, 2016).

Again, this discussion shows that the role of the science park, especially through interactions with the university, could help develop the RIS, particularly in the peripheral region developing-economy context, in addition to the gaps with regards to literature in the specific RIS–university–science park context. However, there have also been a limited number of studies exploring the roles and interaction of universities in the RISs of peripheral regions more generally. Table 3.3 indicates the limited number of papers that have discussed these issues, which will be used to focus discussion of the research conducted in this thesis. This table also shows, however, that these previous studies also largely focus on developed economies, again reinforcing the existence of a gap in the literature for developing-economy regions.

TABLE 3.3: ROLES OF UNIVERSITIES AND INTERACTIONS IN PERIPHERAL RISS

References	Universities (regions, countries)	Roles in peripheral RISs
García-Aracil & De Lucio (2008)	Universities (Valencia, Spain)	They offered advisory and technical support, education and training personnel, joint R&D, as well as engagement in contract R&D.
Franz Tödtling & Sedlacek (1997)	Technical University and Montanuniversität Leoben (Stylia, Austria)	They supported technology transfer. Montanuniversität Leoben had applied research contracts with firms.
Doloreux & Dionne (2008)	Institute of Agri-Food Technology and La Pocatière college (La Pocatière, Canada)	They encouraged applied research and technology transfer.
Pavlova & Burenina (2017)	Universities (Tomsk, Russia)	They hosted conferences and exhibitions to exchange information. They participated in joint and contract research, as well as cooperated with firms in technology platforms and regional clusters.

3.4 Roles of science parks/technology parks/innovation centres in the RISs of peripheral regions

Prior studies illustrate the roles of science parks/technology parks/innovation centres in the peripheral RISs of developed-economy countries and can be classified into two main streams: 1) the group of studies indicating the roles and interactions of the science park but without university involvement in the interaction, and 2) the group of studies showing the roles of science parks and interactions with the university.

First, previous studies portray the roles of the science park/technology park and its interactions without the university. According to Tödtling and Sedlacek (1997), the Styrian Technology Park (STP) was set up in Graz (Austria), acting as a start-up incubator, providing support services (secretary, telephone, fax, databases and conference rooms) as well as consultancy. As can be seen from the Quebec (Canada) case, a technology park is one component of the Technocentre, its role being to provide low cost, full facility, firm accommodation, the park housing only three firms in the fields of textile and industrial automation (Doloreux, 2002). Hence, these prior studies indicate that science parks or technology parks are separate elements that support the main actors in peripheral RISs of developed-economy countries.

Secondly, prior studies indicate the roles of the science park/technology park and its interactions with the university. With respect to Brown (2016), eight innovation centres have been set up by the Scottish Government to be based at Scottish universities for aiding the commercialisation process in Scotland. From the case of a peripheral RIS in the information and communication technology industry in Arendal (Norway), Ericsson and local technical colleges established the centre of a new technology park, which included more than 40 firms and organisations; in particular, the incubator organisation operated a support programme to stimulate commercialisation of research results from the technical colleges (Isaksen, 2001). In sum, prior studies portray that the interactive innovation process in the RIS–university–science park nexus has been less emphasised in the context of RISs in peripheral regions of developed-economy countries and there is limited evidence demonstrating this phenomenon.

As the science park does not appear to have an important role in the peripheral RIS of developed-economy countries, the interactive innovation process among actors could occur through the interaction between actors in 'specialist programmes'. For instance, the NT programme encourages the interaction between firms and R&D institutions both in and outside of Northern Norway (Asheim & Isaksen, 1997; see Table 3.4 for an operational process of the NT programme).

Summing up, less emphasis on using the science park-based approach in peripheral RISs of developed-economy contexts has been observed; the RIS–university–science park nexus is a predominantly core region phenomenon. Indeed, this review reveals only a single study focusing on this issue in the broad context of the RIS, and therefore, while the Asheim & Isaksen (1997) study will be used in the analysis and discussion of results, this also highlights a key gap in the literature.

TABLE 3.4: AN OPERATIONAL PROCESS OF THE NT PROGRAMME (ASHEIM & ISAKSEN, 1997)

The NT programme in the RIS of Northern Norway
1) The operational process of the NT programme started by selecting Northern Norwegian firms most strongly innovation oriented, whilst also having the financial and human resources necessary to undertake development projects.
2) The programme then provided 'all-round support firms', including financial support, advice and guidance in many fields, as well as assistance in finding partners for cooperation on projects.
3) The programme, finally, has 'the active follow-up of firms and projects' and 'the follow-up in long periods of time' for firms that have several projects running at one time.

3.5 Differences between the roles and relationships of universities-science parks/technology parks/innovation centres in the RISs of peripheral regions and those of core regions

The engagement of universities in the RIS of a core region is usually through 'informal links'. According to Boucher, Conway, & Van Der Meer (2003), universities in core regions participate on boards of technology parks and other regional institutions, showing a tendency to have a more informal basis. There is also evidence that most institutions, such as universities, science parks, research institutions, innovation centres, and technology parks, are located in the core regions/largest cities where an abundance of resources and industrial capabilities is available. For example, the 53 technology parks in China are mainly located in the metropolises/core regions (Hu, 2007). Consequently, universities and science parks in core regions are likely to benefit from a more fully operational RIS.

In terms of the engagement of universities in peripheral regions, they usually engage in through university technology transfer, as to 'institutionalise informal personal relations into formal and strategically planned networks' (Boucher et al., 2003). For instance, the University of Limerick in Ireland links with the National Technology Park and the regional development organisation, Shannon Development, developing a 'multitude of inter-intuitional linkages and regional network' for attracting international and local science and technology based firms to Limerick and promoting collaborative projects between the university and local firms (Boucher et al., 2003).

In comparison with the RIS of a core region, the roles and relationships of universities-science parks, as well as the innovation processes in the peripheral RIS have not been encouraging, because of the lack of relevant actors, such as support organisations and innovative firms in system (organisational thinness) (Doloreux et al., 2009). Supported by the comparative study of Doloreux (2004), the region of Ottawa, a core region, has the availability of public organisations including universities (University of Ottawa and Carleton University), the National Research Institute (nine in Ottawa), the Ottawa-Carleton Research Institute, the Ottawa Centre for Research and Innovation, four technological incubators, 12 venture capital organisations, two science parks, etc. to enhance the regional innovation competence. In comparison, Beauce, a peripheral region, lacks the relevant regional actors making the activities in RIS of Beauce rely on one college (CEGEP Beauce-Appalaches), one Technocentre made up of an industrial motel, a virtual business incubator and a science park with only three tenants. Likewise, the RIS of Dytiki Ellada, a peripheral region in Greece, has a few innovation actors including three HEIs, three public research institutes, one science park, as well as one incubator unit and, within the RIS, local authorities and HEIs have limited expertise to link academic excellence with the needs of firms in the region (Komninaki, 2015).

3.6 An overview of the RIS in developing-economy countries and the comparison with the RIS in developed economy countries

There has been increasing interest in the rapid growth of certain regions in developing countries, especially China and India, but less attention has been paid to the role of the RIS in supporting this rapid growth (Chaminade & Vang, 2008). Also, according to Asheim and Vang (2011), a limited number of studies focus on the relevance of the RIS approach for socially cohesive economic development in developing economy contexts. Consequently, both Asheim and Vang (2011) and Chaminade and Vang (2008) studied the RIS of Bangalore (India), as one of the most remarkable cases of regional economic development in Asia. From the analysis of the 'emerging Bangalore RIS', none of the systemic aspects of the RIS were found to be strong in the system, and interactive learning with other firms, customers and universities were not sufficiently developed (Chaminade & Vang, 2008).

While the study of Asheim and Vang (2011) was conducted later, their findings demonstrate that Bangalore has a dense organisational setting which has made it the centre for advanced science and military research. The successful economic development of Bangalore came from good local universities, highly developed human capital infrastructure, efficient regional government and well-educated engineers. Therefore, the studies of Asheim and Vang (2011) and Chaminade and Vang (2008) illustrate the development of an RIS in Bangalore from an emerging phase to a later phase.

In the case of China, innovation systems at the regional and provincial level have also been transitioned. This included a rapid increase in R&D and innovation activities, beginning to take the leading position in R&D spending by firms, co-existing dual innovation systems where one is an upper-level innovation system focusing on the development of advanced technology and another is a lower-level innovation system focusing on locally embedded industries, as well as an increased variation in regional innovation performance (Li, 2009).

As the key component in RISs, universities have different roles and interactions in various countries and regions. Some previous studies have indicated the roles and interactions of universities in the RISs of developing countries, mostly conducted in China. According to

Jiao, Zhou, Gao and Liu (2016), the university can directly contribute to RIS performance in addition to being a basic research agent. In China's emerging economy, the university supports regional innovation through producing innovation for commercialisation. In the case of Shanghai's RIS, the government upgraded the standard of local universities which increasingly became involved in research collaboration with firms in the biotech and telecommunications industries (Asheim & Vang, 2011). Hence, RISs in China have very strongly used universities to encourage the functioning of systems, highlighting the strong role of government.

In Beijing's RIS, universities have close relationships with industry through joint projects, professional consulting, training and, in the case of THU, the building of a science park as an incubator to develop start-ups (Chen & Kenney, 2007). The spin-off firms from this science park can access science and technology resources and university facilities, as well as help commercialise research results and offer internship opportunities for students. This indicates that science parks in the Chinese context have a strong role in the functioning of the RIS, but focus on the most developed parts of the country – the core areas.

Overall, therefore, there have been limited numbers of studies illustrating the roles of the university in the RISs of developing-economy countries (see Table 3.5). Building on the previous discussion, this highlights that studies of RISs in developing economies have focused on core regions, and mainly concern the Chinese context. The studies identified will be used within the analysis and discussion of the results of the current research. However, this finding also further emphasises the need for specific research to close the gap with regards to universities and RISs in the peripheral region developing-economy context.

TABLE 3.5: ROLES OF UNIVERSITIES IN THE RISS OF DEVELOPING-ECONOMY COUNTRIES

References	Roles of universities in RISs of China
Jiao, Zhou, Gao, & Liu (2016)	University supports regional innovation through the production of 'deliverable innovation' for commercialisation.
Asheim & Vang (2011)	In Shanghai's RIS, local universities are increasingly involved in research collaboration with firms in the biotech and telecommunications industries.
Chen & Kenney (2007)	In the RIS of Beijing, universities have close relationships with industry through joint projects, professional consulting and training, and THU built a science park as an incubator to develop start-ups.

In terms of RIS, universities and science parks in the context of a developed economy are likely to benefit from a longer standing innovation system (at both national and regional levels). The study of Buesa et al. (2006), for example, found that Madrid was the region in Spain that has the most complete innovation system, including 14 universities, more than 100 research centres, a high concentration of science parks and technology parks, as well as innovation intermediaries, such as the FUEs (*Fundaciones Uniniversidad-Empresa*), University-Enterprise Foundations located in the regional universities with the role to develop a permanent link with enterprise, OTRIs (*Oficinas de Transferencia de Resultados de Investigación*) and Offices for the Transference of Research Results located in universities and research centres, and CDTs (*Centros de Difusión Tecnológica*) that encourage innovation activities between SMEs in the region. Likewise, the authorities in the Netherlands promote 'innovation regions' which contain mature science parks devoted to R&D and high-tech activities, established by private sector or public-private initiatives (Huang & Fernández-Maldonado, 2016). According to Bigliardi et al. (2006), AREA Science Park (Scientific Park of Trieste) is the largest science park in Italy and managed by a consortium comprising the Friuli Venezia Giulia Region, the municipality of Trieste, the provincial administration of Trieste, the National Research Council, the two universities in the region including the University of Trieste and the University of Udine and other scientific and cultural organisations to promote the development of AREA Science Park and establish links with external institutions, as well as developed programmes with national and international scientific research institutions. All of these examples demonstrate the benefits to universities-science parks from well-established RISs in developed economy countries.

In comparison, the interaction between RIS-university-science park actors in the RISs of developing-economy countries has been limited. For example, from the survey by the World Bank (2004), the collaboration between Malaysian firms and local universities/research institutes is less than 10%, due to university research not meeting with the needs of firms and most firms not considering the links with university as the key factor influencing their decision to locate in Technology Park Malaysia (Malairaja & Zawdie, 2008). In the case of Thailand, the NSTDA (National Science and Technology Development Agency) is located among the outstanding universities (Asian Institute of Technology, Sirindhorn International Institute of Technology, Thammasat University, Rangsit University, Bangkok University) in the core region. It has set up Thailand Science Park to help SMEs commercialise R&D results and enhance technological capabilities, however, the key obstacles for NSTDA is the 'multiple layers of government bureaucracy' making NSTDA unable to effectively turn the knowledge into the type best able to support firms and start-up companies (Wonglimpiyarat, 2010). Despite the potential to benefit the regional economy, these examples show that RISs in the context of developing-economy countries have not been well-developed, the roles and relationships of RIS-university-science park actors and, even, government needing to be compatible with the needs of firms in the region in order to develop the RISs of developing-economy countries.

3.7 Overview of RISs in the Thai context

Identified in the pre-study research, Northern Thailand is the only peripheral region in Thailand where firms, the university and science park are collaborating, and thus it was chosen as the focus of this thesis. In order to fill the gap in the literature, this thesis therefore explores the specific NT-RIS, considered as a peripheral region in a developing-economy country, and illustrates the roles of the university (CMU) and interactive innovations in the NT-RIS. The next section therefore provides background information on the RIS in Thailand.

3.7.1 Previous studies on Thailand's innovation systems (NIS and RIS)

Previous studies on Thailand's NIS have concentrated on examining the system's characteristics (actors and links). With respect to Intarakumnerd, Chairatana and Tangchitpiboon (2002), firms, government and universities have the main role in shaping Thailand's NIS. However, firms were characterised by low-capabilities and not being enthusiastic in developing their own innovation, while the research in universities often has little industrial relevance (Habaradas, 2011; Intarakumnerd et al., 2002). In terms of the linkages among actors, they are weak and fragmented, divided into: 1) weak user–producer linkages, 2) weak co-operation between firms in the same and related industries, 3) low technological spill-overs from transnational corporations, 4) weak industry–university links, 5) weak links between public research technology organisations and firms, 6) training by government institutions that fails to upgrade the technical expertise of firms' employees towards the higher end, and 7) government fiscal and financial incentives that are ineffective in stimulating private-sector demand for investment in technology development (Intarakumnerd et al., 2002).

There has been some transitioning in the Thai NIS (Intarakumnerd, 1983; Intarakumnerd et al., 2002). For instance, some large firms increased their R&D activities, while smaller firms are starting to collaborate with universities to increase their competitive advantage. Additionally, new start-up firms have been emerging. Thai public universities have also attained autonomous status since 2002. Intarakumnerd (2005) examined how the innovation system can be transformed into a stronger and more coherent one, as well as identified what the contributing factors to such a transformation are. His findings from the experience of the Thai NIS indicate that the NIS of a developing economy can transform from one with long-standing weaknesses, fragmentation and slow-learning into one with stronger, more-coherent and more-active learning but only with significant changes to the behaviour of key actors that can then generate positive changes in other actors. In conclusion, the Thai NIS is still in the developing phase, and recent studies on the NIS of Thailand have been lacking, which makes it a useful context in which to study the issues under discussion.

Prior research focused on Thailand's RIS has, however, been limited, with most studies concerned with the links between university and industry in various regions. Schiller (2006) studied the potential impacts of five universities in three regions of Thailand and asserted that universities have crucial roles in regional development but also that processes of regional university–industry knowledge transfer are still limited. Secondly, Schiller (2006) found a gap between the 'absorptive capacities of firms' and the 'knowledge production of universities' within the innovation system of regions in Thailand, suggesting ways to upgrade the innovation system by enhancing firm endeavours to build technological capabilities, improving capabilities of universities through long-term sustainable investment in equipment and staff development, as well as strengthening co-operation relationships between university and industry. According to Intarakumnerd and Schiller (2009), the links between university and industry in regions of Thailand and technical support from universities are, however, still weak, with most projects between universities and firms limited to consulting and technical services. Summing up, prior research shows that RISs in Thailand have been nascent and limited, especially in terms of links and interactions among actors, again suggesting that the Thai context will allow a full examination of the research questions developed in Chapter 2.

3.7.2 The development of RISs in Thailand

Starting in the early 2000s, a major shift in the Thai Government and policy regime occurred as a new National Science and Technology Strategic Plan (2004–2013) was introduced. Concepts of the NIS, industrial clusters and stimulating innovation were the backbone of this plan (Intarakumnerd, 1983). Moreover, strategy 1 of this plan focused on cluster development to upgrade the regional economy, developing an RIS based on the 'One Tambon One Product (OTOP)' slogan (Yokakul & Zawdie, 2009). One of the measures also aimed to promote the establishment of science parks in main regions of the country (see Figure 3.1).

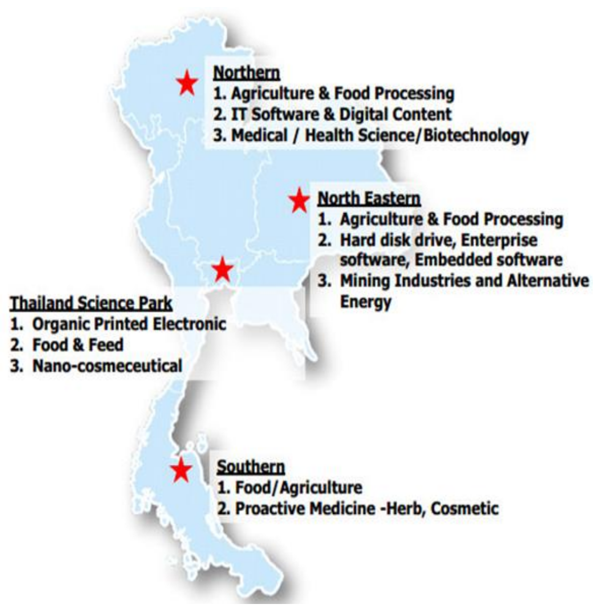

FIGURE 3.1 LOCATION OF SCIENCE PARKS IN THAILAND AND THEIR STRATEGIC INDUSTRIES

Source: Chatratana, 2013

After that, the National Science, Technology and Innovation Policy and Plan (2012–2021) was established and, strategy 5 in particular, focused on 'Science, Technology and Innovation (STI) infrastructure development' by supporting STI development zones (e.g., science parks, science cities, research institutions etc.), and encouraging the development of STIs at regional levels through area-based collaborative networking of government agencies, academic institutions, private entities and local governments. In sum, government agencies have more recently attempted to strengthen innovation systems (both NISs and RISs) in Thailand by launching supportive policy and plans.

To promote linkages among actors in innovation systems, the Ministry of Science and Technology (MOST) set up the Science and Technology Infrastructure Database (STDB) to disseminate information from universities, researchers and infrastructure to all actors in the system. Additionally, the National Science, Technology and Innovation Policy Office ran the Talent Mobility Programme to facilitate the mobility of academic personnel into industry.

There have, however, been a relatively limited number of policies promoting the functioning of an RIS in Thailand. Additionally, most universities in the regions of Thailand have functioned based on the traditional roles of teaching and generating knowledge through research. As a result, a lack of links and interactions among actors in RISs has been observed and shown in prior studies. To improve RISs in Thailand, the context and nature of each region should therefore be investigated.

From initial discussion with policy experts and sponsors (i.e., the pre-research phase), Northern Thailand is the only peripheral region in Thailand where there is evidence of a history of firms collaborating with the science park and university and, hence, informed the rationale for the selection of this region for the present study. The next section provides details on the specific NT-RIS.

3.8 Northern Thailand context

3.8.1 Background of Northern Thailand

The Northern part of Thailand is considered a peripheral region because it has Gross a Regional Product (GRP) of THB billion 1,182.8 (£30.3 billion), which is only 7.65% of the THB billion 15,451.9 (£395.88 billion) of Thailand's total in 2017,[1] compared to population figures of 11,400,000 persons, or 16.85%, of the 2017 total of 67,654,000 persons for the whole kingdom. As a result, the average monthly income per household of Northern Thailand in 2015 was THB 18,952.3 (£454.7), which ranked fifth in Thailand's regions behind Greater Bangkok, Central region, North-eastern region and the Southern region.[2] This identifies Northern Thailand, therefore, as a peripheral region.

The total area of Northern Thailand is 93,690.85 km^2 (36,174.24 sq mi) – 33% of the area in Thailand. Northern Thailand has 17 provinces (see Figure 3.2), which can be divided into the upper- and lower-northern areas. The upper-northern area comprises eight provinces, including Chiang Mai, Chiang Rai, Mae Hong Son, Lamphun, Lampang, Phayao, Nan and Phrae. In particular, 'Chiang Mai' is the centre for industry, manufacturing, services, tourism and transportation for the region. The lower-northern area includes nine provinces, including Kamphaeng Phet, Tak, Nakhon Sawan, Phichit, Phitsanulok, Phetchabun, Sukhothai, Uttaradit, and Uthai Thani. In terms of geography, the upper-northern area has high mountains, forest and water sources, but the lower-northern area has river plains.

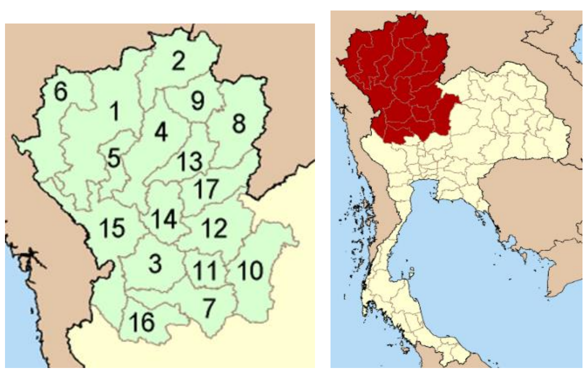

FIGURE 3.2 NORTHERN THAILAND

(Retrieved from https://en.wikipedia.org/wiki/Northern_Thailand)

[1] Office of the National Economic and Social Development Board (NESDB).

[2] Office of the National Economic and Social Development Board (NESDB).

Northern Thailand is linked with the Greater Mekong Sub-Region Economic Corridors and the ASEAN (Association of Southeast Asian Nations) economic community. In terms of transportation, Northern Thailand has highways linking to the main transportation of Thailand and connecting to neighbouring countries. It has railways between Bangkok, the capital city, and Chiang Mai as well as two international airports and ten domestic airports. Additionally, Northern Thailand has power plants and a water supply covering all areas.

This background is relevant because the economic structure of Northern Thailand has been driven by the service sector and agriculture. The local economic crops of this region are rice, bananas, sugar cane, cassava and rubber. There are a lot of agro-processing industries, including agro-processing of rice, sugarcane and cassava. However, industry in both the upper- and lower-northern areas continue to face challenges. For instance, local firms are trying to increase their competitiveness in the manufacturing sector and services, as well as improve the quality of agricultural products and develop new products from local economic crops. Consequently, government agencies set up regional science parks (RSPs) to collaborate with universities in Northern Thailand to bring STI knowledge from universities to industry. However, most of these science parks are young, operating for less than five years.

STeP, located in Chiang Mai province, is the only RSP in Northern Thailand that has spin-off firms commercialising new products from specialist programmes in both Thailand and international countries. Moreover, since 2013, STeP has collaborated with CMU, the most prestigious university in this region and, as a result, they have generated data over the longest timeframe. This is, therefore, a good context in which to conduct the study. As such, this thesis defines the interactions between STeP, CMU and other actors in Northern Thailand as a surrogate for a specific RIS.

3.8.2 The NT-RIS

There are four main actors in the NT-RIS, including firms, CMU, the science park (STeP) and government agencies.

3.8.2.1 Firms

Government agencies have identified the strategic industries of Northern Thailand: (1) creative industries, such as information technology (IT) software and digital, ceramics, furniture and textiles; (2) the agro-industry and food processing; (3) rice; (4) tourism; and (5) health and medicine. Therefore, firms in this region are reliant on these industries. Because of the establishment of RSPs and the promotion of university–industry linkages by government agencies, this will allow firms to increasingly collaborate with local universities to strengthen their competitive advantage.[3]

3.8.2.2 Chiang Mai University

CMU was the first institution of higher education in this region, founded in January 1964 under a Royal Charter granted by His Majesty King Bhumibol Adulyadej.[4] It is a public university with a strong emphasis on engineering, science, agriculture and medicine. The university ranks fourth in Thailand (QS University Rankings: Asia (2018)) or third in Thailand (THE-Asia University Rankings 2018). Its ranking in Asia is 112 (QS University Rankings: Asia (2018)) or 201–250 (THE-Asia University Rankings 2018). In terms of its world ranking, the CMU ranks 551–600 (QS Global World Ranking (2018)) or 801–1000 (THE-World University Rankings 2018).

CMU had 35,509 students in January 2017. The educational levels include undergraduate, graduate, professional and continuing education, offered through resident instruction. It has a total of 21 faculties, three colleges and four research institutions within four campuses.

CMU's vision is: *'Chiang Mai University is a Leading University with Academic Excellence in International Standards, focusing to become a research-oriented institution of higher education and producing graduates with high moral and ethical standards, equipped to*

[3] Document from SPA, The Development of National Science Park Strategy (2013–2017) (in Thai).

[4] https://cmu.ac.th/en/engaboutcmu.php?id=2

practice good governance under the Sufficiency Economy Philosophy and Sustainable Development.' [5] It has a five-fold mission:

1. To provide higher education and high-level professional education emphasising academic excellence and quality of graduates with high moral and ethical standards under the Sufficiency Economy Philosophy.
2. To conduct research in various fields to support standards of teaching, learning and technology transfer for the social and economic development of the region and the country.
3. To provide academic services to the national community in line with the Sufficiency Economy Philosophy, particularly for Northern Thailand.
4. To preserve and nurture our religious and cultural heritage, and develop the resources of the unique natural environment of Northern Thailand.
5. To develop the University's administration systems and management under the Sufficiency Economy Philosophy while aiming at Sustainable Development.[6]

CMU creates academic linkages or research networks with universities both in Northern Thailand and other parts of the country. In addition, it offers academic services to firms to transfer knowledge from university to industry, as well as helps firms to solve problems in their business by using the knowledge of science and technology.

CMU now has a research development strategy focused on research commercialisation, as indicated in the Educational Development Plan: Phase 12 (2017–2021) that, '*CMU will focus on 3 pro-active strategies which are Environment and Energy, Food and Health and Lanna (Northern Thailand) Innovation with the aim to produce research based on social needs and benefits'*.[7] Due to CMU's academic sources of knowledge, it collaborates with the science

[5] https://cmu.ac.th/en/engaboutcmu.php?id=3

[6] https://cmu.ac.th/en/engaboutcmu.php?id=4

[7] https://cmu.ac.th/hotnews_extra_detail_eng.php?act_id=164

park (STeP) and allows researchers to participate in STeP programmes. In sum, CMU encourages interactive learning among actors in the NT-RIS.

3.8.2.3 Science park (STeP)

Located in the CMU campus, STeP was renamed from the Technology Development Center for Industry at the end of 2012. It has been an official organisation under CMU since 2013 and collaborates with seven faculties, including the Faculty of Engineering, Faculty of Science, Faculty of Agriculture, Faculty of Agro-Industry, College of Art, Media and Technology (CAMT), Faculty of Architecture and Faculty of Business Administration. Moreover, it also has links with six other local universities (Maejo University, Mae Fah Luang University, University of Phayao, Naresuan University, Uttaradit Rajabhat University and Pibulsongkram Rajabhat University) and operates by mechanisms of collaboration between public–private organisations and the academic sector. STeP aims to enhance the capabilities of firms in Northern Thailand’s main industries, including: 1) the industries relevant to plants, vegetables, fruit, northern Thai herbs and rice; 2) the agro-processing industry of agricultural products, herbal cosmetics and food processing; 3) medical and biotechnology industry; 4) IT software and digital content industry, tourism, design and creative industries; and 5) environmental, renewable energy and innovative materials industries.

In order to strengthen the knowledge economy, enhance the competitiveness of firms in Northern Thailand and encourage the commercialisation of research results, STeP provides R&D services to firms. The specialist services of STeP can be divided into four programmes (see Table 3.6). In summary, STeP acts as an intermediary organisation by connecting with firms, knowledge producers and other actors in the specific NT-RIS. It also enhances the linkages and supports the interactive innovation processes among actors through specialist programmes.

TABLE 3.6: THE FOUR MAIN PROGRAMMES OF STEP

STeP programmes	Summary of services and support provided in programmes
THE SERVICE PLATFORM	This ‘one-stop service’ provides firms with laboratory testing and technical services, packaging development, labelling, logo and design services, as well as IP consulting and management.
STI BUSINESS INCUBATION	To support spin-offs and start-ups, the incubation programme provides firms with consulting services, seminars and specialist training for business. The duration of this programme is approximately three years per firm. Additionally, firms in this programme can access and use the infrastructure of CMU.
IRTC PROGRAMME	To enhance the R&D capabilities of firms in various industries, STeP provides technical experts or CMU researchers who can undertake R&D activities for solving firms’ problems or developing firms’ new products for commercialisation. The duration of this programme is normally 12–15 months per project between the firm and CMU researcher. Also, firms in this programme can access and use CMU infrastructure, as well as attend seminars and training in business.
CO-RESEARCH PROGRAM	STeP supports collaborative projects between firms and academia by using the resources of CMU. This programme is suitable for firms and experts from various universities in Northern Thailand to undertake large, collaborative projects that need a long duration (3–5 years). Additionally, firms in this programme can access and use CMU infrastructure, as well as participate in seminars and training in business.

3.8.2.4 Government agencies

SPA is a public agency controlled by MOST. It was established in 2011 by regulation of the Prime Minister. SPA is responsible for developing policies and plans to support all RSPs in Thailand. It also has the role of evaluating the performance of RSPs, as well as provide funding for them. This agency is considered to be one of the RIS actors in the specific NT-RIS because it directly supports STeP operations.[8] There have been other organisations that collaborate with STeP and CMU in the NT-RIS, such as the Federation of Thai Industries Chiang Mai Chapter, the Chiang Mai Chamber of Commerce, Industrial Promotion Centre Region 1, Chiang Mai Municipality, and so on.[9]

[8] Document from SPA, The Development of National Science Park Strategy (2013-2017) (in Thai).

[9] Document from SPA, The Development of National Science Park Strategy (2013-2017) (in Thai).

3.9 Conclusion

This chapter has provided an overview of the RISs of peripheral regions, the roles of universities and science parks in peripheral RISs, as well as reviewed the RISs of developing countries. It has identified literature of relevance to use when discussing the results of this thesis – especially in terms of the context of peripheral region developing-economy RISs. Also, the chapter provides background information on RISs in the Thai context, which emphasised the specific NT-RIS. Overall, the RISs of Thailand have been emerging and the links among actors are still weak.

Focusing on the NT-RIS, government agencies have attempted to develop and strengthen links among actors by establishing a science park and specialist programmes. The government recently implemented a new plan, the National Science, Technology and Innovation Policy and Plan (2012–2021). Only strategy 5 of this plan (which focuses on 'Science, Technology and Innovation (STI) infrastructure development' and encourages 'the development of STI at regional levels' through collaborative networking of government agencies, universities and private sector[10]) has been considered to support the innovation system.[11] Hence, Thailand has a limited number of supportive policies to encourage the functioning of RISs. Consequently, the NT-RIS is still in a developing phase. By exploring, specifically, the NT-RIS, this thesis will therefore fill the gap in the literature on RISs in the sense of illustrating an RIS in a peripheral region of a developing-economy country, providing empirical evidence of the roles of the university and interactions within the RIS–university–science park nexus in the NT-RIS. The next chapter of this thesis outlines the research methodology used to address and answer the research questions in order to fill this gap.

[10] http://www.sti.or.th/encontent.php?content_type=3

[11] National Science Technology and Innovation Policy Office

Chapter 4: Research Methodology

4.1 Introduction

The preceding chapters highlighted the importance of investigating the roles of the university within the context of a peripheral RIS within a developing country and, specifically, the context of Northern Thailand. To address the research questions, this thesis first employed a systematic literature review approach to build the two-dimensional matrix illustrating the roles of the university and relationships between RIS–university, RIS–university–science park and university–science park actors. Due to the RIS and the relationships among actors being different in each specific region and country, the matrix needs to be applied to analyse the roles of the university and its relationships with other actors in specific regions. Therefore, this thesis will use the two-dimensional matrix as an analytical framework to explore the roles of CMU and the relationships within the RIS–university–science park nexus in Northern Thailand.

As will be seen, the research for this thesis discussed in this chapter can be divided into three phases. Phases 1 and 2 follow an integrated approach. As for phase 3, it is the comparative analysis, comparing the evidence from phases 1 and 2 with evidence in the literature related to the roles of universities and relationships among actors, from which to establish the contributions of the thesis.

This chapter, begins, however, with a brief discussion of the research questions to be addressed in the study as well as the ethical considerations, followed by a broad discussion of the methodological options, criteria of appropriateness and then an outlining of the methods used in the study.

4.2 Research context and relevance to research questions

The preceding chapter included a description of the specific NT-RIS. The RIS consists of four main sets of actors, including firms, CMU, STeP and government agencies. STeP was chosen because it is the only RSP in Northern Thailand through which spin-off firms have commercialised their new products from its programmes in both Thailand and international countries. Due to STeP collaborating with CMU since 2013, it has generated data over the longest timeframe. As this thesis aims to explore the roles of universities and relationships between actors in a peripheral region, Northern Thailand was chosen because it is the only peripheral region in Thailand where firms have collaborated with the science park and university. Also, Thailand was chosen because the government started developing RISs and science parks in the country's regions 7–8 years ago. There are also specific policies in place. For example, the National Science, Technology and Innovation Policy and Plan (2012–2021) aims to decentralise STI infrastructures and enhance the collaboration between the public and private sectors.

Having identified Thailand as the geographical focus of the study, the research questions are as follows.

Research question 1 (RQ1):

RQ1: What are the specific roles of the university and relationships between the RIS, university and science park actors?

The objectives of RQ1

The objective of the first research question was to develop a two-dimensional matrix identifying the roles of the university in its RIS–university, RIS–university–science park, and university–science park relationships. This was undertaken in the literature review chapter (see Chapter 2). Additionally, this two-dimensional matrix will be applied to analyse the empirical evidence for answering the second and third research questions.

Research question 2 (RQ2):

RQ2: What are the specific roles of the university and relationships between the RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?

The objectives of RQ2

The second research question aims to identify the extent and the ways in which a two-dimensional matrix applies to the region of Thailand (the case-specific context). This will include identifying if there are any specific roles of the university and its interactions, as demonstrated in the cells of the two-dimensional matrix, being emphasised more than others. In sum, the second research question will allow the identification of the roles of the university during its RIS–university, RIS–university–science park, and university–science park relationships within a peripheral region developing-economy context.

The third research questions (RQ3a and RQ3b):

RQ3a: What are the roles of the university in its relationships between the RIS, university and science park actors in innovation projects conducted with on-park firms?

RQ3b: How does the university contribute to the innovation activities of on-park firms in the context of a peripheral region developing economy?

The objectives of RQ3

The objectives of the third research questions are to identify the extent and the ways in which the roles of the university in the two-dimensional matrix (from cell 1 to cell 8) apply to the interactive innovation processes within the specific NT-RIS, as well as to specific examples (more successful and less successful case studies) of projects between the university and spin-off firms[12] from two main STeP programmes (the Business incubator and IRTC programme). Also, RQ3a and RQ3b identify the success-driving factors that influence the roles of the university in generating the commercialisation of research results.

Research question 4 (RQ4):

RQ 4: How do the university and science park contribute to the development of a peripheral RIS in a developing economy?

The objective of RQ4

The objective of this research question is to uncover the roles of the university and relationships between the RIS–university–science park actors in Northern Thailand and contrast the roles identified with those evident within the existing literature (identified in Chapter 3). In doing so, it will provide greater understanding of the RIS–university–science park nexus within a peripheral region developing-economy context.

4.3 Research sponsorship

This research project has been sponsored by the Royal Thai Government Scholarship. The Government of Thailand has established this scholarship to support Thai students enrolled in higher education programmes outside Thailand. Funding is provided for 3–4 years for PhD students. The degree programmes funded are required to be concurrent with the demands of Thai Government agencies regarding skilled personnel. The recipients may be

[12] Spin-off firms in this thesis are defined as firms that "graduated" from either the collaboration programme between firms–CMU–STeP or finished at least one project between firms–CMU–STeP. Some of these firms continued to participate in other STeP programmes at the time the researcher undertook the interviewing. The term 'spin-off' has been used because this was the term used by the interviewees themselves to describe the firms the participated in the science park programme and that subsequently left the parks.

contractually obliged to work for the Thai Government upon returning from abroad.[13] Therefore, the researcher will be assigned as a policy and plan analyst at SPA under the Office of the Permanent Secretary, MOST, after graduation.

Due to the RIS and RSPs in Thailand being developed, the Thai Government provided a scholarship to the researcher to study the roles of the university and interrelationships between the RIS–university–science park actors in the chosen region of Thailand. This sponsorship provided background understanding for the research project, understanding of the Thai RIS and the peripheral RIS of Thailand, emphasising the roles of the university and relationships among actors in the NT-RIS. Also, the empirical evidence and findings from this research project have policy implications for relevant government agencies.

4.4 Research design

4.4.1 Ethical considerations

Before beginning data gathering, the University of Portsmouth Ethics form was completed. Thus, the research design of this thesis was reviewed and approved by the Ethics Committee. In terms of specific ethical issues which affected the process of the research, informed consent (which informs the research topic), the aims, the method to collect data and who will see the results, were gained from the participants. Moreover, participants were informed about their right to withdraw from the research. Confidentiality has been ensured through the security measures undertaken to protect the data collected by using the coding of data to hide individual and organisational identity. The relevant documents related to this are contained in the appendix (see Appendix 3).

[13] http://www.european-funding-guide.eu/scholarship/2433-royal-thai-government-scholarship-program-offered-ocsc

4.4.2 Identification of the methodological options

Prior to commencing the data collection for the study, the appropriate research design and methodological options were considered by the researcher. The methods adopted in this thesis had to enable the research questions to be answered within the constraints of the time and financial resources available to the researcher. In addition, it was also determined that the study should also build on previous research in this topic area, and therefore be guided by the methods adopted in that research. To design the research, it was crucial to consider the appropriate philosophy, research approach, methodological choice, strategy, time horizon, as well as techniques and procedures (see Figure 4.1).

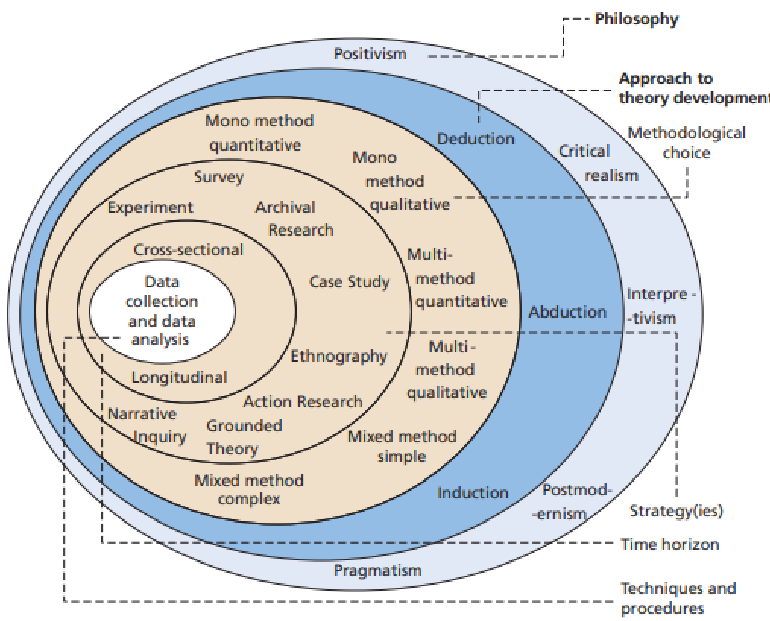

FIGURE 4.1 THE RESEARCH ONION (SAUNDERS, LEWIS, & THORNHILL, 2019)

4.4.3 Ontological, epistemological and axiological assumptions

There are generally perceived to be three types of research assumptions, ontology, epistemology and axiology, to distinguish research philosophies. The details are provided as follows:

1) Ontology refers to assumptions about the nature of reality that shape the way in which the researcher sees and studies research objects (these research objects in business and management, for example, organisation, management, organisational events etc.) (Saunders et al., 2019).
2) Epistemology refers to assumptions about knowledge which are concerned with the way that the researcher understands the world and how researchers can communicate this understanding as knowledge to others (Burrell & Morgan, 2016).
3) Axiology refers to the roles of values and ethics. According to Saunders et al. (2019, p. 134), *'One of the key axiological choices that you will face as a researcher is the extent to which you wish to view the impact of your own values and beliefs on your research as a positive thing'.* Therefore, Saunders et al. (2019) conclude that the researcher will need to consider how to deal with their own values and those of the people they are researching.

4.4.4 Research philosophy: Interpretivist epistemology

Based on the limited previous research in this area, this thesis is exploratory in nature. Hence, an interpretivist epistemological approach was adopted (see Table 4.1 for an overview of the main philosophies compared by the assumptions). According to Leitch, Hill and Harrison (2010, p. 70), *'Interpretivist inquiry, therefore, attempts to embrace the complex and dynamic quality of the social world and allows the researcher to view a social research problem holistically, get close to participants, enter their realities, and interpret their perceptions as appropriate'.*

As interpretivism emphasises complexity, richness, multiple interpretations and meaning-making, it is explicitly subjectivist, asserting that social reality is made from the perceptions and consequent actions of social actors (people) (Saunders et al., 2019). This thesis was constructed upon the existing literature on science parks and RISs to produce the two-dimensional matrix used to identify the roles of the university and its relationships with other actors in the RIS. Moreover, it followed a belief that the social world can only be understood from the perspective of the participants involved in the interactions within the RIS–university–science park nexus. This highlights the interpretivist epistemological approach.

Cavaye (1996, p. 232) indicates that *'the interpretative stance aims to understand phenomena from the point of view of participants directly involved with the phenomenon under study'*. This thesis is based on the exploratory approach. It therefore followed the interpretivist epistemology by seeking to explore the roles of the university, the relationships between actors and the factors affecting the roles of the university in more successful and less successful projects between university researchers and firms.

TABLE 4.1: Four main philosophies compared by assumption (Adapted from Saunders, Lewis, & Thornhill, 2012, p. 146)

	Pragmatism	**Positivism**	**Realism**	**Interpretivism**
Ontology (researcher's view on the nature of reality)	External, multiple, most appropriate view chosen for answering the research question.	External, objective and independent of social actors.	Objective – exists independent of human thought or knowledge about their existence (realism) but is interpreted through social conditions (critical realism).	**Subjective, socially constructed, may alter, multiple.**
Epistemology (researcher's view on acceptable knowledge)	Depending on the research question, either or both, observable phenomena and subjective meanings can provide acceptable knowledge.	Only observable phenomena enable the production of facts and credible data. It focuses on causality and law-like generalisations.	Observable phenomena provide credible data and facts. Insufficient data means inaccuracies in sensations (realism) or phenomena create sensations which are open to misinterpretations (critical realism). It focuses on explanations within a context.	**Subjective meanings and social phenomena. Focus on details of a situation and its reality, subjective meanings motivating actions.**
Axiology (researcher's view on the role of values in research)	Large role of values in interpreting results. A researcher takes both an objective and a subjective view.	Value-free research with the researcher being objective and independent of the data.	Value-laden research because the researcher is biased concerning worldview, cultural experiences and background, which affect the research.	**Value-bound and subjective. The researcher is part of what is researched and cannot be separated.**

4.4.5 Research approach

This thesis followed the integrated approach of Ali and Birley (1999, p. 105), who argue that:-

> '*there can be a middle ground – one where existing theory is used but is presented in the form of constructs rather than variables. This would be synergistic with the qualitative approach to research, since the whole tenor of a data gathering exercise which is premised on constructs rather than variables can be more fluid and adaptive to the needs of the respondent. This enables the researcher to "discover" issues or effects which they may not have had in mind when the investigation began*'.

The integrated approach starts with developing the theoretical framework based on constructs; the researcher then converts the framework into atheoretical questions, allowing respondents to discuss the seemingly general questions and identify constructs which are meaningful to them as well as to explain the relationships between the constructs (Ali & Birley, 1999). Incorporated within this thesis, the conceptual framework or matrix was developed from a systematic literature review, which then inspired designing the interview instruments which participants can use to expand on what the roles and relationships of the university are in the NT-RIS.

The integrated approach is different from the inductive approach, which Rowlands (2005, p. 86) defines as: *'the researcher tries not to be constrained by prior theory and instead sees the development of relevant theory, positions, and concepts as a purpose of the project'*. It also differs from the deductive approach, which is a theory-testing process initiated from an established theory or generalisation and seeks to see if it applies to specific instances (Hyde, 2000). Table 4.2 illustrates the integrated approach compared to purist versions of the deductive and inductive approaches from the study of Ali and Birley (1999).

TABLE 4.2: THE INTEGRATED APPROACH COMPARED TO PURIST VERSIONS OF THE DEDUCTIVE AND INDUCTIVE APPROACHES (ALI & BIRLEY, 1999)

Stage	Purist deductive	Purist inductive	Integrated approach
1.	Develop a theoretical framework	Area of enquiry identified but no theoretical framework	Develop a theoretical framework based on constructs
2.	Variables identified for relevant constructs	Respondents identify constructs and explain the relationship between them	Some variables identified for relevant constructs – others can be identified by respondents
3.	Instrument development	Broad themes for discussion identified	Researcher converts the a priori theoretical framework into atheoretical questions
4.	Respondents give answers to specific questions	Respondents discuss general themes of interest	Respondents discuss the seemingly general questions and identify constructs which are meaningful to them and explain the relationships between the constructs
5.	Answers analysed in terms of a prior theoretical framework	Researcher develops theory on a purely inductive basis	Respondent data analysed according to existing theory OR theory is developed on an inductive basis – without regard to the existing theory
6.	**Outcome** Theory tested according to whether hypotheses are accepted or rejected	**Outcome** Theory developed	**Outcome** Either Existing theory is adapted OR An alternative theoretical framework is presented

4.4.6 Methodological choices, strategies and time horizon

The results of the systematic review revealed that a number of studies examining both science parks and RISs adopted qualitative approaches. Following the approaches of these prior studies, this research also adopts semi-structured personal interviews, as used by Albahari, Catalano and Landoni (2013), Chordá (1996) and Vedovello (1997), and follows the case study method adopted to study science parks or RISs in a number of countries (e.g., Chan & Lau, 2005; Hansson, Husted, & Vestergaard, 2005; Ratinho & Henriques, 2010; Yoon, Yun, Lee, & Phillips, 2015; Zhang, 2015). This research therefore is also qualitative and takes place in three phases for answering the second, third and last research questions (see Table 4.3).

TABLE 4.3: SUMMARY OF PHASES 1, 2 AND 3 OF DATA COLLECTION

	Phase 1	Phase 2	Phase 3
Aims	To overview the roles of the university, the relationships between those in the RIS-university–science park nexus as well as the policies to promote the roles of the university and the relationships between them and the other key stakeholders	To investigate the roles of the university in the actual innovation process between actors in each project and the factors affecting the roles of the university within a peripheral region developing-economy context	To contribute to the literature on science parks–RIS, and the roles of universities, and linking this literature together by providing evidence from the RIS–university–science park nexus within a peripheral region developing-economy context
Research Approach	Qualitative interviews with key informants	Case study research (Qualitative interviews and secondary data collection)	comparative analysis
Research Strategy	Interviews	Case studies	Comparison between evidence of this thesis with literature
Sample	Interviews with (1) entrepreneurs of on-park firms (2) executives of university and science park (3) RIS actors such as the policy and plan analysts from SPA and the entrepreneurs of spin-off firms	Interviews with (1) researchers from the university involved in chosen projects (2) entrepreneurs of spin-off firms	Evaluate (1) The observed roles of the university and relationships in the specific region of Thailand (from the first and second phases) (2) The evidence in existing literature (from Chapter 3)
Research Instrument	Semi-structured interviews and secondary data	Semi-structured interviews and secondary data	Comparison between evidence of this thesis with that in the literature
	To answer RQ2: What are the specific roles of the university and relationships between the RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?		
	To answer RQ 3a: What are the roles of the university in its relationships between the RIS, university and science park actors in innovation projects conducted with on-park firms? **To answer RQ 3b:** How does the university contribute to the innovation activities of on-park firms in the context of a peripheral region developing economy?		
	To answer RQ 4: How do the university and science park contribute to the development of a peripheral RIS in a developing economy?		

4.4.7 Techniques and procedures

4.4.7.1 Data collection

There are multiple units of analysis in this thesis. With regards to the first research question, the unit of analysis entails the identification of the roles of the university during its RIS–university, RIS–university–science park, and university–science park relationships from existing literature. Thus, the first research question was answered by constructing a two-dimensional matrix using a systematic literature review approach (see Chapter 2).

As for the second research question, the unit of analysis covers ‘all roles’ played by the university during its relationship within the RIS–university–science park nexus, while the unit of analysis for RQ3a and RQ3b covers ‘all observed interactive innovation processes’ among actors. Therefore, phase 1 provides an ‘overview’ of the roles played by the university and the innovation processes among actors observed by the key stakeholders. When combined with phase 2, which was established to focus on the roles of the university and the interactive innovation processes within ‘each project’ between researchers and spin-off firms from STeP programmes, the phases complement one another to demonstrate ‘all roles played by the university’ as well as cover ‘all observed interactive innovation processes’ among actors. Consequently, this will reveal which roles are the ‘specific roles’ of the university, answering the second research question (by comparing phase 1 data, phase 2 data and the evidence from existing literature in each cell of the matrix), and illustrating the innovation processes among actors, answering RQ3a and RQ3b (by comparing phase 1 data and phase 2 data).

In the case of the last research question, the unit of analysis also includes a comparison of the evidence from both phases 1 and 2 with the evidence from the existing literature (literature in Chapter 3) in order to illustrate the contribution of this thesis in terms of the context of an RIS in a peripheral region of a developing economy.

More details of the data collection methods in phases 1, 2 and 3 are described below.

4.4.7.1.1 PHASE 1 DATA COLLECTION METHODS

This phase was designed to give an 'overview' of the roles of the university, the relationships between those in the RIS-university–science park nexus as well as the policies to promote the roles of the university and the relationships between them and the other key stakeholders.

Kvale (1983) saw the purpose of qualitative interviews as being to obtain an understanding of the real-world facing the interviewee, particularly with regards to their interpretations of described phenomena. The key to any qualitative interview is, therefore, to view the research topic from participants' perspectives, to understand how and why they come to their points of view (King, 2004, p. 11). The characteristics of qualitative interviews should be the imposition of a low degree of structure by the interviewer, a preponderance of more open questions, and a focus on specific situations and action sequences facing the interviewee (Kvale, 1983).

In this thesis, semi-structured interviews were employed as they are a versatile, flexible, popular (Kallio, Pietilä, Johnson, & Kangasniemi, 2016) and relatively easy (Wengraf, 2001) data collection method, suitable when people's perceptions and opinions are complex (Barriball & While, 1994). By conducting semi-structured interviews, it is possible to emphasise the issues that are most meaningful for participants, allowing them to express diverse perceptions (Cridland, Jones, Caputi, & Magee, 2015). For this research, this approach allowed the roles of the university and its interrelations to be revealed from the viewpoint of participants. In addition, their opinions, for example, in terms of the reasons for some of the roles played by the university and the relationships seen as most significant, were also illustrated.

In sum, the first phase of this thesis consisted of semi-structured interviews, both face-to-face and telephone interviews, with the key informants. Documentation, such as internal documents of the science park, university and SPA, as well as published reports, were also used to supplement the data collection from semi-structured interviews.

INTERVIEWEE SAMPLE SELECTION FOR PHASE 1

The researcher conducted a systematic literature review. Many of the studies on science parks and RISs recruit participants who hold key roles in the science park and university. These include the managers of science parks, managers of national associations of science parks, directors of TTOs at universities involved in a science park and expert/scholars of science parks both at the national and local level (Albahari et al., 2013), as well as park management, R&D managers, on-park firms and researchers from the university (Vedovello, 2002).

This research, therefore, followed the existing literature to recruit informants based on their key roles in the RIS. The participants of the first phase comprised:

(1) entrepreneurs of on-park firms (to acquire information of their motivations to collaborate with the science park and university, services received and the relationship experience with these two actors)

(2) executives of the university–science park (to obtain their perspectives of the roles and interactions between RIS actors-university-science park as well as the involved policy to promote the linkage between these actors). These actors play dual roles as they are also part of the university hierarchy.

(3) RIS actors, such as the policy and plan analysts from SPA and the entrepreneurs of spin-off firms (to obtain information on the interactions and the observed roles played by the university; also, policymakers can provide details of policies to promote linkages within the science park–university–RIS nexus).

In terms of recruitment, executives of the university–science park and the policy and plan analysts were recruited through expert sampling, as a sub-category of purposive sampling. The participants were selected due to knowing more about the community/organisation than other people, or through a key informants sampling approach (Payne & Payne, 2004). Therefore, these personnel were recruited because they have roles relevant to the development of the science park and university, in particular they realise the roles and interactions among the RIS–university–science park actors as well as the policy involved to promote the linkages between them.

The entrepreneurs of on-park firms and the entrepreneurs of spin-off firms were recruited by using convenience sampling as the sample size is small, the strategy of convenience sampling, allowing speedy, resource efficient, convenient identification of interviewees for study (Patton, 1990).

There were also inclusion criteria used to recruit the participants. First, the entrepreneurs of on-park firms should have attended the university–science park programmes for at least 9 months to one year. Secondly, the executives of the university and science park and the policy and plan analysts from SPA should have duties directly related to the development of the science park and university performance. Lastly, the entrepreneurs of spin-off firms should have graduated from the programmes not more than three years ago and still have contact with university and science park staff.

As for exclusion criteria, the researcher excluded entrepreneurs of on-park firms that were newly attending the university–science park programmes. Executives of the university and science park and the policy and plan analysts from SPA who were not involved or did not perform duties related directly to developing science park and university performance were also excluded. Lastly, entrepreneurs of spin-off firms who graduated from the university–science park programmes more than three years ago and/or did not have contact with university–science park staff were excluded.

Through conducting a systematic literature review, the researcher found that the number of participants in studies of science parks and RISs varied due to the context of each study. For example, Lew et al. (2018) conducted semi-structured interviews with six interviewees with senior managers and policymakers from provincial government, firms and academic institutions. In contrast, Hommen, Doloreux and Larsson (2006) conducted 50 interviews in their case study of Mjärdevi Science Park; Díz-Vialand and Montoro-Sánchez (2016) conducted, overall, 76 interviews in their case study of the Madrid Science Park. Given this variety, the number of planned participants in this thesis fits within the boundaries and is as follows:

The data collection period for the first phase of this thesis ran from January to March 2018. It consisted of 15 semi-structured interviews both face-to-face and by telephone with entrepreneurs of on-park firms (four persons) (see Table 4.4), executives of the university–science park (four persons) (see Table 4.5), policy and plan analysts from SPA (three persons) (see Table 4.6) and entrepreneurs of spin-off firms (four persons) (see Table 4.7). The interviews were approximately one hour in length, and were recorded and then translated from Thai to English. Handwritten notes were also made throughout the interviews.

Due to the science park being established in 2013, the number of on-park firms and spin-off firms participating in the STeP and CMU collaborative programme is limited (approximately 5–10 per year). There were also a total of five executives from the university–science park and three SPA policy and plan analysts who were relevant to the roles of the university and relationships within the RIS–university–science park nexus. Therefore, 15 semi-structured interviews with key informants were deemed sufficient to achieve a broad range of perceptions of the roles of the university, the relationships in the RIS–university–science park nexus and the policies used to promote the roles of the university and its relationships.

TABLE 4.4: LIST OF INTERVIEWEES (ON-PARK FIRMS)

Interviewees	Role of firms	Firm size	Industrial sector	Length of interview
OPF1	Managing director	Large (Over 300 employees)	Food and beverage	50 mins
OPF2	Managing director	SME (Not more than 20 employees)	Biotechnology	1 hour
OPF3	Entrepreneur	SME (Not more than 10 employees)	Food and beverage	50 mins
OPF4	Entrepreneur	SME (Not more than 10 employees)	cosmetics	1 hour

TABLE 4.5: LIST OF INTERVIEWEES (EXECUTIVES OF UNIVERSITY–SCIENCE PARK)

Interviewees	Position in STeP	Role in CMU	Length of interview
UPE1	Director of STeP	Lecturer from Faculty of Engineering, CMU	1 hour
UPE2	Assistant Director of STeP	Lecturer from Faculty of Engineering, CMU	55 mins
UPE3	Deputy Director of STeP	Lecturer from Faculty of Engineering, CMU	1 hour
UPE4	Assistant Director of STeP	Lecturer from Faculty of Engineering, CMU	50 mins

Table 4.6: List of interviewees (policy and plan analysts)

Interviewees	Position in SPA	Length of interview
PPA1	Director of SPA	1 hour
PPA2	Science park promotion and support manager	1 hour 8 mins
PPA3	Policy and plan analyst	50 mins

Table 4.7: List of interviewees (spin-off firms)

Interviewees	Role of firms	Firm size	Industrial sector	Length of interview
SOF1	Managing director	Large (Over 300 employees)	Food and beverage	1 hour 5 mins
SOF2	Entrepreneur	SME (Not more than 50 employees)	IT software	52 mins
SOF3	Entrepreneur	SME (Not more than 50 employees)	Animal Food	1 hour
SOF4	Chief Executive Officer	Large (Over 300 employees)	Food and beverage	58 mins

INTERVIEW INSTRUMENTS FOR PHASE 1

The researcher developed a two-dimensional matrix, which presented the roles of the university and its relationships with the actors in the RIS identified from the systematic literature review approach. The matrix is used as an analytical framework to analyse the empirical roles and relationships of CMU. Therefore, the interview questions were developed based on this two-dimensional matrix and the studies from both the literature on science parks and RISs (Gunasekara, 2006; Lew, Khan, & Cozzio, 2018; Ratinho & Henriques, 2010; Vedovello, 1997) (see Appendix 1 for the interview guide).

The research developed four sets of questions for university–science park executives, SPA policy and plan analysts, entrepreneurs of on-park firms and entrepreneurs of spin-off firms. The first set of questions for the university–science park executives started with introductory questions about the organisation and its relationships with other stakeholders in the region, followed by questions related to the roles and relationships of the university in which the university–science park executives were involved (cells 1 to 9). The second set of questions for SPA policy and plan analysts started with introductory questions about the organisation and its relationships with other stakeholders in the region, followed by questions related to the roles of the university and the relationships between RIS actors and the university as well as the RIS–university–science park actor relationships that SPA policy and plan analysts were involved in (cells 1, 2, 4, 5, 7 and 8). The third set of questions for entrepreneurs of on-park firms started with questions related to the roles of the university and the RIS–university–science park actors and university–science park relationships that entrepreneurs were involved in (cells 2, 3, 5, 6, 8 and 9). The last set of questions for entrepreneurs of spin-off firms started with questions related to the roles of the university and RIS–university and RIS–university–science park actor relationships that entrepreneurs were involved in (cells 1, 2, 4, 5, 7 and 8).

4.4.7.1.2 PHASE 2 DATA COLLECTION METHODS

The second phase was designed 'more specifically' to investigate the roles of the university in the innovation process between actors in actual projects and the factors affecting the roles of the university within a peripheral region developing-economy context.

According to the type of research question, the case study method is suitable for the explanatory phase of investigations and to answer questions that start with 'how' and 'why' (Yin, 1989). The case study is considered to be a research approach focused on understanding the dynamics present within individual settings (Eisenhardt, 1989). It can also make a conceptual contribution by employing the case study as an illustration and can sharpen existing theory by pointing to gaps and filling them (Eisenhardt & Graebner, 2007). As stated by Flyvbjerg (2004, p. 428), '*the advantage of case study is it can "close-in" on real-life situations and test views directly in relation to phenomena as they unfold in practice'* .

For researchers who conduct single case studies, where theory matches the details of the specific case, the single case study approach enables the creation of more complicated theories than multiple case studies (Eisenhardt & Graebner, 2007). Cavaye (1996, p. 237) demonstrates that *'The case itself (e.g. an organisation) may provide the setting, but within that setting several instances of the phenomenon may be present'.* This thesis, therefore, views the science park as the case within which exist collaborative projects between researchers in a university and firms as embedded cases.

According to Rowley (2002, p. 22), *'Embedded designs identify a number of subunits (such as meetings, roles or locations) each of which is explored individually; results from these units are drawn together to yield an overall picture'.* The comparison between the observed subunits of analysis within one case can bring out theoretical constructions (Yin, 1989). Hence, this thesis identifies a number of subunits in the form of collaborative projects which demonstrated the roles of the university and relationships between RIS–university–science park actors.

The second phase of this thesis, therefore, consists of in-depth cases of more and less successful projects that researchers from the university undertook with firms in STeP programmes between 2014 and 2017. Researchers and firms participating in the business incubator and IRTC programme were interviewed and asked to identify factors that they consider to be important to the roles of the university in commercialising research results. Also, documentation such as internal documents of STeP, the university and SPA as well as published reports were also used to supplement the data collection from the semi-structured interviews.

SELECTION OF THE CASES FOR PHASE 2

The participants in the second phase comprised:

(1) Researchers from the university involved in the chosen projects.

(2) Entrepreneurs of spin-off firms[14] who participated in programmes provided by the science park (IRTC Programme).

The researchers and entrepreneurs of spin-off firms were recruited through convenience sampling. Specifically, entrepreneurs of spin-off firms[15] were recruited based on the availability of their existing contacts as well as personal contacts.

As for the inclusion criteria, the university researchers were those with the main roles in the projects, while entrepreneurs of spin-off firms must have graduated from the programme not more than three years ago and were able to be contacted by university–science park staff. Moreover, spin-off firms were firms which sold their products in the local market or presented their product in international countries or sold their product in

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[14] Spin-off firms in this thesis are defined as firms that 'graduated' from either the collaboration programme between firms–CMU–STeP or finished at least one project between firms–CMU–STeP. Some of these firms continued to participate in other STeP programmes at the time the researcher undertook the interviewing. The term 'spin-off' has been used because this was the term used by the interviewees themselves to describe the firms participating in the science park programmes.

[15] Due to the science park being newly established in 2013, the number of spin-off firms participating in the collaborative programme of STeP and CMU was limited (approximately 5–10 persons per year).

international markets or had graduated from the programme but had not commercialised their product. In terms of exclusion criteria, researchers who did not have main roles in the projects and entrepreneurs of spin-off firms that had graduated from the programme more than three years ago and/or could not be contacted by university–science park staff were excluded.

There has been only one relevant scheme running (IRTC Programme) that researchers from the university can participate in with firms in collaborative projects. 14 firms had been through the programme completely which met the inclusion criterion. All firms who were willing to participate were recruited (the three firms that did not were contacted by the gatekeeper but declined the opportunity). In addition, the Science Park's own Incubation Programme was found to be relevant but only for the one firm which engaged with CMU (the incubation programme normally did not require university involvement) for facilities and was located on the science park at the time of the intervention, identified by the gatekeeper.

By conducting the systematic literature review, the researcher found that the number of case studies in the literature on science parks and RISs vary. For example, Hansson, Husted and Vestergaard (2005) selected two in-depth case studies of science parks in Denmark and the UK, while Chan and Lau (2005) conducted multiple case study research in Hong Kong by collecting data from incubating companies.

In this thesis, the case study element was conducted between April to June 2018. It consisted of 21 semi-structured interviews (nine face-to-face interviews with researchers and 12 telephone interviews with entrepreneurs of spin-off firms; see Appendix 1 for the interview guide) to construct in-depth case studies of more successful and less successful projects that the CMU researchers undertook with spin-off firms (see Table 4.8). A number of cases (12 case studies) were chosen based on the availability of spin-off firms due to the science park being newly established in 2013, limiting the total number of spin-off firms available. Interviews were typically 1–1.5 hours in length, which were recorded and then transcribed. In addition, secondary data were gathered from internal documents and published reports of SPA, MOST and CMU to supplement the data collection.

TABLE 4.8: LIST OF INTERVIEWEES (FIRMS AND RESEARCHERS) INVOLVED IN PHASE 2 AND THE SUMMARY OF CASE STUDIES SELECTED

Case	Interviewees			
	Firm	Role in firm	Researcher	Role of researcher
1	A1	Managing director	Researcher A	Lecturer from Faculty of Agro-Industry, CMU
2	A2	Entrepreneur	Researcher B	Researcher from the STRI, CMU
3	A3	Chief Executive Officer	Researcher G	The deputy director of Food Innovation and Packaging Centre (FIN), CMU and Lecturer from Faculty of Agro-Industry, CMU
4	A4	Entrepreneur	Researcher C	Lecturer from Faculty of Science, CMU
5	A5	Managing director		
6	A6	Entrepreneur	Researcher D	Associate Professor of Mechanical Engineering and Lecturer from Faculty of Engineering, CMU
7	A7	Project manager	Researcher E	Director of Knowledge and Innovation Centre and Lecturer from College of Arts, Media and Technology (CAMT), CMU
8	A8	Entrepreneur	Researcher F	Head of Department of Product Development Technology and Lecturer from Faculty of Agro-Industry, CMU
9	A9	Entrepreneur	Researcher G	The deputy director of FIN, CMU and Lecturer from Faculty of Agro-Industry, CMU
10	A10	Entrepreneur		
11	A11	Entrepreneur		
12	A12	Managing director	Researcher H	Lecturer from Faculty of Agriculture, CMU

Case	Project	Sector	Received service from the CMU/STeP	Nature of the project	Project outcome	Patent registration	Firm			CMU		State of development (the recent position)
							Interviewee	Firm size	Previous experience with the CMU	Interviewee and the expertise	Role	
1	The development of traditional Thai instant coffee for enhancing commercial competitiveness and exporting (Year of project started to Year of project finished 2014–2015)	Food and beverage	- R&D activities - Funding	- R&D intensive - Process development	New process and product	No	Managing director	Large (Over 300 employees)	Yes	Researcher A (Food technology)	Lecturer from Faculty of Agro-Industry, CMU	The product has been selling in the international country and Thailand.
2	The probiotic fermented sausage (E-sarn sausage) (Year of project started to Year of project finished 2014–2015)	Food and beverage	- R&D activities - Funding	- R&D intensive - Process development	Improved process and product/ Knowledge for production	No	Entrepreneur	SME (Not more than 50 employees)	Yes	Researcher B (Applied microbiology)	Researcher from the STRI, CMU	The product has not been launched. (The firm needs to consider the preparation of the bacterial strain and to test the amount of probiotic bacteria for overall production.)
3	‘Kombucha’, a snack from the by-product of fermented tea production (Year of project started to Year of project finished 2014–2015)	Food and beverage	- R&D activities - Funding	- R&D intensive - Process & product development	New process and product/ New packaging	No	Chief Executive Officer	Large (Over 300 employees)	No	Researcher G (Product development)	The Deputy Director of Food Innovation and Packaging Centre (FIN), CMU and Lecturer from the Faculty of Agro-Industry, CMU	The product has not been launched. (looking for an original equipment manufacturer or OEM)

4	The production of paper mâché from rice straw for SME (Year of project started to Year of project finished 2015–2016)	Materials science	- R&D activities -Funding	- Machinery development - Process & product development	Improved process and product/ Knowledge for new production process/ New developed machines	No	Entrepreneur	SME (Not more than 20 employees)	Yes	Researcher C (Materials science)	Lecturer from Faculty of Science, CMU	The product has been selling in overseas and in Thailand.
5	The prototype from a by-product of solid surface and the chemical formula development for production of the new solid surface and its coating (Year of project started to Year of project finished 2016–2017)	Materials science and chemistry	- R&D activities -Funding	- Applied research - Process & product development	Improved process/ Prototypes/ Knowledge for production	No	Managing director	Large (Over 300 employees)	Yes			The product has not been launched. (The prototype was 95% complete by the end of the programme.)
6	The development of an eco-friendly oven for drying chilli (Year of project started to Year of project finished 2016–2017)	Mechanical engineering	- R&D activities - Funding	- Machinery development	Developed machine for production	No	Entrepreneur	SME (Not more than 10 employees)	Yes	Researcher D (Mechanical engineering)	Associate Professor of Mechanical Engineering and Lecturer from Faculty of Engineering, CMU	The developed machine can be used in the production line.
7	The modular farm mobile application for agro-industry (Year of project started to Year of project finished 2016–2017)	IT software and agriculture	- R&D activities - Funding	- Mobile application development	Prototype of mobile application	No	Project manager	SME (Not more than 50 employees)	Yes	Researcher E (Informatics)	Director of Knowledge and Innovation Centre and Lecturer from College of Arts, Media and Technology (CAMT), CMU	The product has not been launched. (The product was 40% complete at the end of the programme.)

8	Yogurt-covered macadamia nuts (Year of project started to Year of project finished 2016–2017)	Food and beverage	- R&D activities - Funding	- Applied research - Product development	New product and Knowledge for production	No	Entrepreneur	SME (Not more than 50 employees)	Yes	Researcher F (Product development)	Head of Department of Product Development Technology and Lecturer from Faculty of Agro-Industry, CMU	The product has been selling in Thailand.
9	A mulberry powdered drink mix (Year of project started to Year of project finished 2016–2017)	Food and beverage	- R&D activities - Funding	- R&D intensive - Product development	New product and Knowledge for production	No	Entrepreneur	SME (Not more than 10 employees)	Yes	Researcher G (Product development)	The deputy director of FIN, CMU and Lecturer from Faculty of Agro-Industry, CMU	The product has not been launched. (looking for OEM)
10	Riceberry macaron with coconut filling (Year of project started to Year of project finished 2016–2017)	Food and beverage	- R&D activities - Funding	- Applied research - Product development	New product and Knowledge for production	No	Entrepreneur	SME (Not more than 50 employees)	No			The product has not been launched. (The prototype was 80% complete by the end of the programme.)
11	‘Easy cup’ the packaging for keeping the quality of Lanna Khao Soi ice cream toppings (Year of project started to Year of project finished 2016–2017)	Food and beverage	- R&D activities - Funding	- Basic research - Product development	New packaging/ Knowledge for the product	No	Entrepreneur	SME (Not more than 10 employees)	No			The product has been selling in Thailand. The entrepreneur presented the product in international countries.

12	The production of sexed semen by using cytotoxic sperm technology for the dairy industry Year of project started to Year of project finished 2014–2015 (IRTC) 2014–present (incubation programme)	Biotechnology	-Laboratory testing services - Business incubation - Funding - Connection with the other organisations	- R&D intensive	Knowledge for new product	No	Managing director	SME (Not more than 20 employees)	Yes	Researcher H (Agricultural sciences)	Lecturer from Faculty of Agriculture, CMU	The product has been selling in Thailand. The managing director presented the product in international countries.

Note: R&D intensive = Basic research + Applied research are defined by the OECD Frascati Manual, Seventh edition, 2015, where Basic research is either experimental or theoretical research primarily undertaken to acquire new, underlying knowledge without specific application or objective, and Applied research is original investigation undertaken to acquire new knowledge primarily directed towards a specific practical aim or use.

4.4.7.1.3 PHASE 3 COMPARATIVE ANALYSIS

As aforementioned, the third phase was proposed in order to specifically identify the contribution of this research that can be generalised from the knowledge gained of the RIS-university–science park nexus in the Thai context. Summing up, this phase compares the evidence from the RIS–university–science park nexus within a peripheral region developing-economy context from both phases with that from existing literature (literature in Chapter 3).

4.4.8 Data analysis for answering research questions

For answering the second research question (RQ2), phase 1 data and phase 2 data are analysed and combined as well as compared with the evidence from existing literature in each cell of the matrix to answer, *'What are the specific roles of the university and relationships between the RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?'*

Further, phase 1 data and phase 2 data are analysed and combined to answer the third research questions (RQ3a and RQ3b) *'What are the roles of the university in its relationships between the RIS, university and science park actors in innovation projects conducted with on-park firms?'* and *'How does the university contribute to the innovation activities of on-park firms in the context of a peripheral region developing economy?'*

To answer the last research question (RQ4), which is *'How do the university and science park contribute to the development of a peripheral RIS in a developing economy?'*, phase 1 data and phase 2 data are analysed and they will be compared with the existing literature from chapter 3.

More details of data analysis are provided as follows:

4.4.8.1 Methods for analysis of phase 1 data for answering RQ2 and RQ3a

Once the data were collected and transcribed, they were analysed through thematic analysis, which is a method for identifying, analysing and reporting patterns (themes) within data (Braun & Clarke, 2006). Using NVivo 11 (a qualitative data analysis computer software) both deductive coding (to code the data for a specific research question) and inductive coding (to code the data without trying to fit it into a pre-existing coding frame) (Braun & Clarke, 2006) were undertaken to identify any themes (cells in the two-dimensional matrix – the analytical framework used) that are presented. Then, the data were matched with each cell in the two-dimensional matrix to provide an overview of the roles/activities of the university and its relationships with other actors. Following this, the number of roles/activities played by the university within each cell of the matrix was counted as a frequency, from which a percentage was calculated (by dividing by a total number of roles/activities, found in each cell from phase 1 data), which was then compared to those of phase 2, aiming to identify the consistency (the differences and similarities of the roles) between both phases (more details regarding the analysis are provided in section 4.4.8.2.1).

By calculating the frequency of each role/activity of the university within each cell of the matrix as a percentage and comparing it with the level of these university roles observed in the existing literature (in terms of references to that role from the evidence in Tables 2.7, 2.8 and 2.9 of chapter 2), CMU's roles were defined as a "strong role", "moderate role" or "limited role" (see the roles of the university and the references in table 6.2 of chapter 6). The results therefore identify the levels of the observed roles, compared with the literature, played by CMU in phase 1. This was process was also undertaken with the data gathered in phase 2. The level of roles played by the university that supported the evidence from existing literature in each cell of the matrix is also compared to those of phase 2 and evidence from existing literature. As a result, the 'specific roles' of the university are revealed to answer RQ2 (more details regarding the analysis are provided in section 4.4.8.2.1).

As the interview guides for phase 1 were also designed to allow participants to illustrate, broadly, interactive innovation processes among RIS–university–science park actors, the processes found from participants' perceptions in phase 1 were coded by matching the roles/activities of the university in each process with cells in the matrix to illustrate the sequence as well as the structure of the process (see Appendix 2). The interactive innovation processes found from phase 1 were used to initially identify the 'emphasis/main role of the university' within the process which gives it its name (see Appendix 2), and were then compared to the interactive innovation process of each case study in phase 2, helping to identify the precise sequencing of cells within the process (for more details of the analysis see section 4.4.8.2.2).

4.4.8.2 Methods for analysis of phase 2 data for answering RQ2 and RQ3 (RQ3a and RQ3b)

4.4.8.2.1 METHODS FOR ANALYSIS OF PHASE 2 DATA FOR ANSWERING RQ2

To answer the second research question (RQ2), the methods for analysis are provided as follows:

- The recorded interviews were analysed through thematic analysis by using NVivo 11 to identify themes (as they relate to the cells) which are presented in the case. Hence, the roles of the university and its relationships observed in each case (phase 2) were matched with the matrix (with each cell) to provide an overview.

- The number of the roles in each cell were then counted as a frequency and compared with those of phase 1 to identify differences and similarities (the consistency) between the data of both phases (see Table 6.1 of Chapter 6) and used to illustrate all of the roles/activities of the university. Comparing all roles of the university observed from both phases with the roles of the university identified from existing literature (evidence in Tables 2.7, 2.8, 2.9 of Chapter 2), the results demonstrated the 'unique characteristics' of the roles of the university in the NT-RIS that are different from those in the literature.

- The number of roles/activities played by the university within each cell of the matrix were also calculated as a percentage to identify the level of roles played by the university (divided into strong role, moderate role and limited role). The levels of roles played by the university from phase 2 that support the existing literature were then compared with those of phase 1 and those within the existing literature, revealing the 'specific roles' of the university that have the levels of roles that are stronger than the others, answering RQ2. The results also provide an overview of the RIS in Northern Thailand.

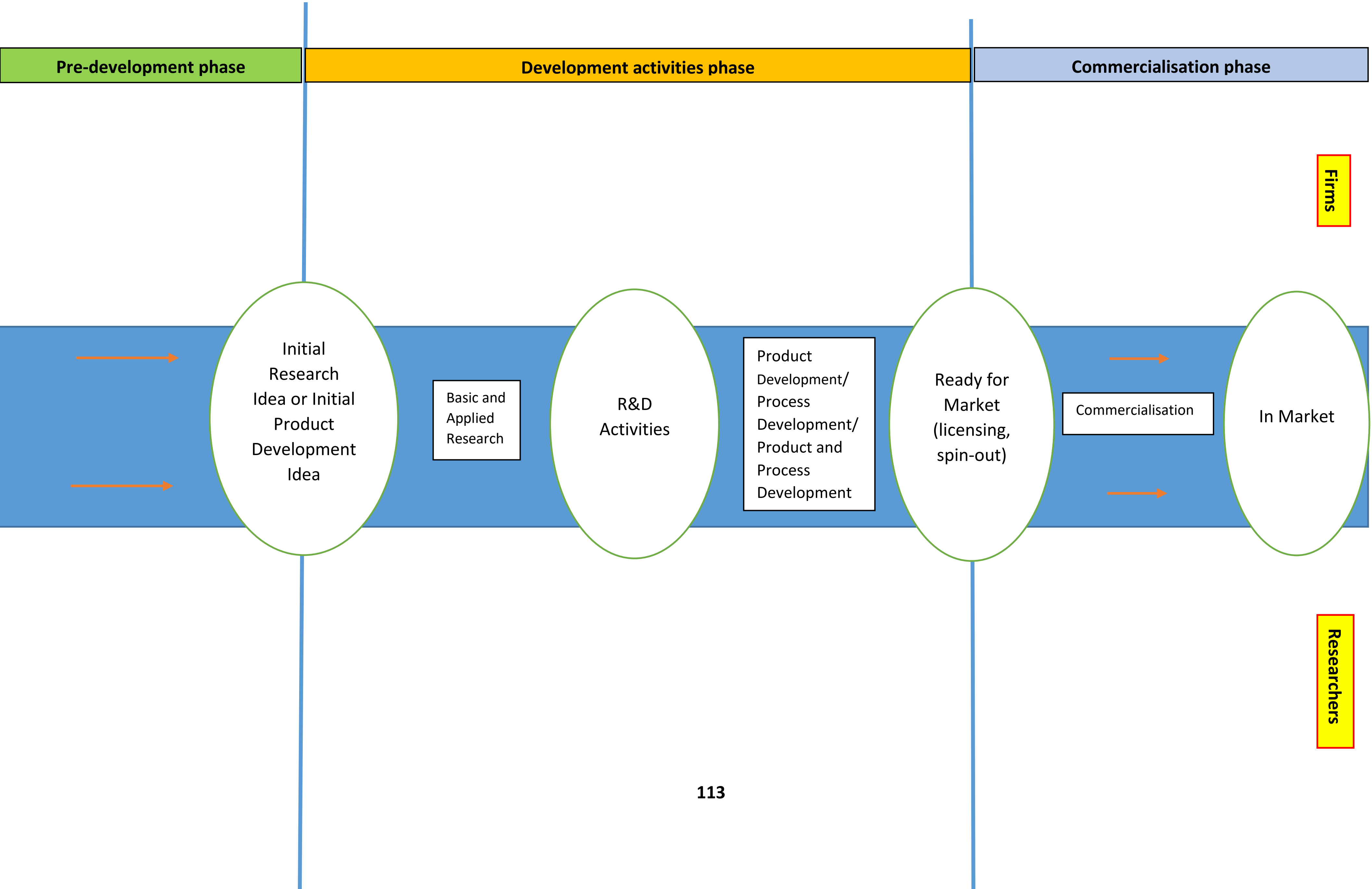
4.4.8.2.2 METHODS FOR ANALYSIS OF PHASE 2 DATA FOR ANSWERING RQ3 (RQ3A AND RQ3B)

The methods of analysis used to answer RQ3a and RQ3b are provided below.

The recorded interviews were analysed through thematic analysis by using NVivo 11 to identify any themes (as they relate to the cells) presented in the case. In terms of analysing the interactive innovation process of each case, the innovative pipeline adapted from McCarthy, Packham and Pickernell (2014) was used as an initial framework (see Figure 4.2). The data from each case study were analysed through thematic analysis, dividing the roles/activities of the university into each cell of the matrix, which were then arranged into a sequence, identifying the process (sequence of the roles/activities of university) based on the pipeline which started with the pre-development phase through to the commercialisation phase. Secondary data were also used to provide a 'rich story' of each project/case study.

To answer RQ3a and RQ3b, the roles/activities of the university found in phase 1, defined as primary or main roles (see the structure of each main role in Appendix 2) were compared with the roles for each project (in terms of the roles used, their sequencing and strength), to identify the interactive innovation process type used in each case. Hence, the researcher followed the approach of cross-case comparison, which is one of the case-oriented strategies for cross-case analysis, dividing the cases into groups/clusters that 'share certain patterns or configurations' (Miles, Huberman, & Saldana, 2014, p. 103). Cross-case analysis was conducted to achieve the required 'thick' description and 'thick' understanding (Abu-Lughod, 1998; Woodside & Wilson, 2003). Miles et al. (2014, p. 101) also summarised the purpose of conducting cross-case analysis, which is 'to enhance generalisability or transferability to other contexts and to deepen understanding and explanation'. In sum, the researcher conducted a cross-case comparison in order to compare the patterns of interactive innovation processes and the relationships among actors, which uncovered the interactive innovation processes of the RIS in Northern Thailand, answering RQ3a and identifying the innovation success-driving factors within each case study, answering RQ3b.

FIGURE 4.2 THE INNOVATIVE PIPELINE (ADAPTED FROM MCCARTHY, PACKHAM, & PICKERNELL, 2014)



4.4.8.3 Methods for analysis of phase 3 for answering RQ2, RQ3 (RQ3a and RQ3b) and RQ4

In terms of the third phase, the evidence from phases 1 and 2 was compared with the existing evidence grasped from the context chapter (Chapter 3 of this thesis) to demonstrate the differences and similarities in the roles of the university and the relationships between actors. This allowed the contributions of RQ2 and RQ3 (RQ3a and RQ3b) to be identified, as well as more specifically, answering RQ4 and also identifying its contribution.

4.5 Conclusion

This chapter identified the research methodology used in this study. It started with the research context, which is relevant to the research questions. Then, the methodological options, research design and data analysis were described respectively. The next chapter presents a broad overview of the data obtained from phases 1 and 2 of the research data collection, followed by Chapter 6, which analyses the data for RQ2, RQ3 (3a and 3b) and RQ4, discussing these results against previous literature and identifying the contributions of the thesis.

Chapter 5: The Roles and Relationships of the University and Findings of Case Studies

5.1 Introduction

This chapter has two main sections which present the findings from phases 1 and 2 of the research for this thesis. The first section gives an overview of the roles played by CMU and its relationships within the RIS–university–science park nexus in Northern Thailand. The second section illustrates the 12 case studies of more and less successful projects that the CMU researchers undertook with spin-off firms from STeP programmes.

5.2 Phase 1: Overview of the roles and relationships of the university

Based on the conceptual framework, the empirical evidence gathered in phase 1 is classified into nine categories (cells) to illustrate CMU's roles and relationships. In essence, this overview indicates that the framework, proposed from the literature, was found to be useful and identified that these activities do occur in this peripheral region developing-economy context but to different degrees depending on the cell in question (discussed in detail in Chapter 6). The findings are presented below.

5.2.1 Cell 1: Providing information

The findings from participants showed that some CMU researchers and firms had a strong personal relationship before attending the STeP programmes. As a result, they exchanged information concerning new products and STeP programmes before the firms entered and/or after the firms graduated from the programmes. This allowed information to flow within the NT-RIS. Moreover, CMU has also provided its information through a database that everyone can access. To support this role, MOST's policy for CMU researchers included adding their details into the database. The example quotes illustrating this role are presented in Table 5.1.

TABLE 5.1: SUMMARY OF FINDINGS FROM PHASE 1 (CELL 1)

The role/s of the university (Resource Sharing Roles)	Theme/s	Illustrative quote/s
cell 1 Provision of Information (RIS actors (SOF, PPA) +University)	Information flow	'I knew [the] researcher before attending the STeP programme because we did prior project in academic service programme of CMU. Firstly, I gave information of my new product to researcher. I cannot do R&D activities by myself because I lacked scientific knowledge. Then, researcher provided information of STeP programme to me. I, finally, decided to participate in the programme for developing my new product' (SOF1). 'Because we have [a] "strong" personal network, I still exchange information of my new product with researcher after spin-off from STeP programme' (SOF1).
	Providing information through a database	'CMU has provided its information, such as the expertise of researchers and their research interest, laboratory equipment etc., to everyone who can access to see details in the Science and Technology Infrastructure Databank (STDB)' (UPE1).
	The supportive policy/strategy	'MOST gave [a]policy to CMU for allowing its researchers to add their details, including research details, resume and research interest, into the STDB. So, everyone can receive information of CMU through this updated database' (PPA2).

5.2.2 Cell 2: Providing communication channels

The findings from participants showed that CMU set up general business and technology seminars as well as offered general business and intellectual property (IP) training to all actors in the NT-RIS as 'channels of communication'. Although CMU undertook these activities, some on-park and spin-off firms did not have any conversations with the other actors. Additionally, there has not been any specific policy or strategy to promote this role of the university. Example quotes illustrating this role are presented in Table 5.2.

TABLE 5.2: SUMMARY OF FINDINGS FROM PHASE 1 (CELL 2)

The role/s of the university (resource sharing roles)	**Theme/s**	**Illustrative Quote/s**
cell 2 Providing the Channels of Communication (RIS actors (SOF, PPA) + University + Science Park)	Providing general business and technology seminar	'CMU provided general business and technology seminar three or four times per year. The seminar is considered to be [the] pathway for CMU to provide channel of communication between university, science park and industry.' (UPE1)
	Providing general business and IP training	'CMU collaborated with STeP and other actors to provide general business and IP training that I consider to be the channel of communication between the researchers from CMU and on-park firms.' (OPF1)
	Casual social exchanges	'I did not have any conversation with both spin-off firms and on-park firms in seminars of CMU.' (OPF1) 'I had a bit social exchanges with on-park firms and researchers in training of CMU. However, I did not have any conversation with other spin-off firms.' (SOF3)
	The supportive policy/strategy	'I did not see the obvious policy or strategy to promote this role of [the] university.' (PPA3)

5.2.3 Cell 3: Providing infrastructure

The findings from participants showed that CMU provided its infrastructure, such as laboratory equipment, CMU café, space or buildings, and so on, to on-park firms and researchers for undertaking collaborative projects. Again, however, there has not been any specific policy or strategy to promote this role. The example quotes illustrating this role are presented in Table 5.3.

TABLE 5.3: SUMMARY OF FINDINGS FROM PHASE 1 (CELL 3)

The role/s of the university (resource sharing roles)	Theme/s	Illustrative quote/s
Cell 3 Provision of Infrastructure (University + Science Park)	Providing laboratory equipment	'I receive the service from the researcher that used the laboratory of CMU.' (OPF2)
	Providing CMU café	'I and [the] researcher used CMU café to be our meeting place for discussing our project.' (OPF4)
	Providing space or buildings	'I used the co-working space of CMU and STeP.' (OPF1)
	The supportive policy/strategy	'I did not see the obvious policy or strategy to promote this role of [the] university.' (PPA2)

5.2.4 Cell 4: Building regional networking

The findings from participants showed that CMU is building its regional network to connect all actors in the NT-RIS through training, internship programmes, mobility of CMU researchers, formal programmes (e.g., CMU researchers participating in the programmes of other organisations/Academic Service (AS) programmes or CMU researchers collaborating in STeP programmes), connection with others organisations as well as setting up conferences and excellence centres. However, there have not been any unified policies or strategies to promote this role. The example quotes illustrating this role are presented in Table 5.4.

TABLE 5.4: SUMMARY OF FINDINGS FROM PHASE 1 (CELL 4)

The role/s of the university (brokering roles)	Theme/s	Illustrative quote/s
Cell 4 Building Regional Networking (RIS actors (SOF, PPA) +University)	Providing of training	'CMU provided training for transferring knowledge and making regional network with firms and other researchers from other universities in Northern Thailand.' (UPE2)
	Internship programme	'CMU students can work with firms through their senior project or as interns. So, the students can transfer the knowledge that they received from CMU to firms and build regional networking.' (UPE4)
	Mobility	'Recently, the National Science Technology and Innovation Policy Office (STI) established the Talent Mobility programme that permitted CMU researchers to work with firms in fulltime. Participated in this programme, researchers and firms can build regional networking. There were approximately 400 firms interested to accept CMU researchers for working with them. However, a number of researchers who participated in this programme were around 100 persons.' (UPE2)
	Formal programmes (Participating in programmes of other organisations/Academic Service (AS) programmes)	'CMU builds the regional networks with them by providing the academic services, such as doing the laboratory services, and collaborating with the other universities in Northern Thailand.' (UPE1)
	Formal programme (Collaborating in the STeP programme)	'CMU collaborated with STeP and it allowed researchers participating in STeP programme for doing R&D activities with firms in the region.' (PPA1)
	Connection with others organisations	'CMU bonding with the others six universities in Northern Thailand as the academic networks. Moreover, the CMU connects with both public and private organisations in the region by receiving the funds from the organisations.' (UPE4)
	Conference	'CMU provides the conferences.' (UPE2)
	Excellence centres	'There were 25 excellent centres established by CMU for serving firms in the region. The centres provided laboratory services and had [a] connection with both public and private sectors.' (UPE3)
	The supportive policy/strategy	'I did not see the obvious policy or strategy to promote this role of [the] university.' (PPA1)

5.2.5 Cell 5: Research collaboration

The findings from participants showed that CMU undertook this role by allowing researchers to participate in joint research projects to undertake R&D collaboration with on-park firms and/or other actors in the NT-RIS. This also highlighted 'the interactive innovation process', as presented in the example quotes (see Table 5.5; see also Appendix 2 for the full structure of the Research Relationship Process emphasising cell 5, obtained via data analysis from phase 1 and phase 2).

CMU also provided specialist seminars to all actors, which allowed them to make connections to undertake research collaboration. However, CMU did not have any specific policy to promote this role. The example quotes illustrating this role are presented in Table 5.5.

TABLE 5.5: SUMMARY OF FINDINGS FROM PHASE 1 (CELL 5)

The role/s of the university (brokering roles)	Theme/s	Illustrative quote/s
Cell 5 Research Collaboration (R&D activities between Actors) (RIS actors (SOF, PPA) + University + Science Park)	Joint research projects/ Doing R&D collaboration	'I participated in the IRTC programme of STeP. Then, I signed the contract with STeP and received additional funding from SPA/MOST. This programme provided me with the CMU researcher from [the] Faculty of Veterinary Medicine to help me doing R&D activities. As I would like to develop my new product, which was the dietary supplements for carp, the researchers helped me to test my recent product, then used testing results for developing the new one. There were other researchers from [the] Faculty of Veterinary Medicine and STeP collaborated in the project. However, I did not participate in any R&D activities. I just received the knowledge related to [the] project from [the] researcher in our meetings.' (SOF3) 'After spin-off from the programme, my product had added-value. I got a new product which was approved by the experts from [a] famous university. So, customers will trust in the quality of my new product.' (SOF3)
	Providing specialist seminars	'I observed CMU providing general business and technology seminars to all actors in Northern Thailand. Some actors have the connections to do research collaboration from these seminars.' (UPE4)
	The supportive policy/strategy	'I did not see any policy to promote this role of [the] university directly.' (PPA3)

5.2.6 Cell 6: Knowledge intermediaries

The findings from participants showed that CMU undertook this role through 'the process', starting with the university providing human resources or the researchers to undertake research collaboration with on-park firms and then the researchers having social contact networks with firms and/or other actors to discuss the projects. After that, some researchers searched for additional knowledge, undertook R&D activities and transferred knowledge to firms; some researchers only undertook R&D activities and transferred knowledge to firms (also see Appendix 2 for the full structure of the Knowledge Transfer Process, emphasising cell 6, obtained via the data analysis in phases 1 and 2). In terms of having a supportive policy, however, CMU did not have any specific policy for promoting this role. Example quotes illustrating this role are presented in Table 5.6.

TABLE 5.6: SUMMARY OF FINDINGS FROM PHASE 1 (CELL 6)

The role/s of the university (brokering roles)	Theme/s	Illustrative quote/s
Cell 6 Knowledge intermediaries (University + Science Park)	Social contact networks	'First of all, I contacted STeP to find [a] potential researcher who can conduct R&D activities for me. Then, STeP identified [a] CMU researcher and I had [a] meeting with him. We discussed about my new product. After that, [the] researcher did [the] R&D activities and transferred knowledge to me. Moreover, we had formal meetings to present the progress of our project. [The] Researcher also gave me the advice and provided knowledge of laboratory equipment, cosmetics, as well as methods to produce my new product. Additionally, I used LINE, telephone calls and email to contact the researcher when I had questions about [the] research results. So, I think [the] researcher in my project acted as [a] knowledge intermediary because he gave me the knowledge from doing R&D activities.' (OPF4) 'There were a lot of benefits. Because [the] researcher is an expert in chemistry and herbs, he can help me and give me valuable advice related to cosmetics. Moreover, [the] researcher helped me [with] testing the extracts from different rice varieties to find which one was the best and suitable to combine into [a] new product. As he got research results, he used them to develop my new product and transferred the knowledge, as well as methods to produce the new product, to me.' (OPF4)
	Providing human resources	
	Consulting	
	Searching for additional knowledge, undertaking R&D activities, and transferring knowledge to firms or undertaking R&D activities and transferring knowledge to firms	
	The supportive policy/strategy	'I did not see the clear policy to promote this role of [the] university.' (UPE3)

5.2.7 Cell 7: Economic development and wealth creation

The findings from participants showed that CMU undertook this role by offering researchers to firms to help them develop their new product ideas, provide knowledge and undertake R&D activities. Furthermore, CMU developed specific policy and strategies to promote this role, including:

1) Having a strategy of researchers producing research results that meet industry needs.
2) Having a strategy where all faculties of CMU provide academic services for general people or firms in Northern Thailand.
3) Having a strategy to increase job opportunities for local people and to promote start-up creations.
4) Having a policy to push the development of research to service the firms in the sectors of food and health, energy and environment, and the creative and craft sectors that are the main industries of Northern Thailand.

The example quotes illustrating this role are presented in Table 5.7.

TABLE 5.7: SUMMARY OF FINDINGS FROM PHASE 1 (CELL 7)

The Role/s of University (Exploitation and Commercialisation Roles)	**Theme/s**	**Illustrative Quote/s**
Cell 7 Economic Development and Wealth Creation (RIS actors (SOF, PPA) +University)	Incubated ideas, educated entrepreneurs and fostered breakthrough technologies	'I got the knowledge and new product which came from the applied research. My business has been increased in sales growth and the profits. I can sell new product and expand the market leading to hire the local people as staff.' (SOF3)
	Policies	'The CMU has the strategy to produce the research results that match with the needs of the industry.' (PPA3) 'The CMU provides the strategy to all faculties of CMU to provide the academic services for general people or firms in Northern Thailand.' (UPE2) 'The CMU also has the strategy to increase job opportunities for the local people and to promote the start-up creation.' (UPE4) 'The CMU has the policy to push the development of research to service the firms in the sectors of food and health, energy and environment, and the creative and crafts that are the main industries of Northern Thailand.' (UPE3)

5.2.8 Cell 8: Development of commercialisation and promoting technological change

The findings from participants showed that CMU set up a Technology Licensing Office (TLO) for a role relevant to IP management. Also, the findings demonstrated 'the process', starting with CMU allowing researchers to do R&D activities for firms, then the new products were developed and CMU offered IP training or provided experts to help firms (also see Appendix 2 for the full structure of the Product Development Process, emphasising cell 8, obtained via the data analysis rom phases 1 and 2). Although CMU provided IP training for all actors in the NT-RIS, some on-park and spin-off firms have not registered their research results as patents because the process of registration is complicated.

In terms of technological change, CMU set up training, conferences and seminars for CMU researchers to update the new technology. Then, the researchers participated in collaborative projects with on-park firms and used their knowledge to produce innovation. This highlighted a way for CMU to promote technological change.

To support this role, CMU had a strategy for researchers to register their research results as patents, petty patents, and copyright. Also, CMU had a policy allowing researchers to use the number of patents claimed as part of their academic position. The example quotes illustrating this role are presented in Table 5.8.

TABLE 5.8: SUMMARY OF FINDINGS FROM PHASE 1 (CELL 8)

The role/s of the university (exploitation and commercialisation roles)	Theme/s	Illustrative quote/s
Cell 8 - Development of Commercialisation (e.g., Licensing Activities, Patents) - Promoting Technological Change (RIS actors (SOF, PPA) + University + Science Park)	Intellectual property management	‘In terms of licensing activities, the CMU has [a] TLO to manage them. So, CMU has the role to protect the rights of researchers. However, STeP do the role between the researchers and firms who want to use that technology.’ (UPE3) ‘Recently, I do not think about patent registration for my research results because the process seems to be complicated.’ (OPF3)
	The process and IP training	‘STeP and CMU had collaboration platforms or the programme that offered additional funding from SPA/MOST to firms and helped firms launching new products. After that, my new products were developed and improved by [a] researcher who did R&D activities, designed [the] new packaging for my product, and tested the developed machinery in my production line. The researcher also transferred the knowledge from [the] project to me. After that STeP/CMU provided experts from [the] university to guide me [through] registering the patent. CMU also offered IP training for both on-park and spin-off firms.’ (OPF3) ‘The programme can help me. My business has been accredited because it was nurtured by the public organisations and [the] university. Customers will trust in my product due to it coming from research results of the outstanding university in Thailand.’ (OPF3) ‘I attended IP training of CMU after spin-off from [the] STeP programme.’ (SOF1)
	Providing a resource for technical research and project-based support (to keep companies in the forefront of technological advances)	‘CMU provides the training, conferences and seminars for the researchers to receive the new knowledge and update the new technology. Further, the CMU let the researcher[s] participate in the project of on-park firms to use their knowledge [to] produce the innovation.’ (UPE4) ‘The researcher conducted the research to develop my product. Then, STeP sent my product as a contestant and let me present my product in the innovation fairs. So, they promoted the technological change. Moreover, STeP sent me the invitation to attend the seminar that updated the new technology to on-park and spin-off firms.’ (SOF1)
	The supportive policy/strategy	‘CMU has [a] strategy to let the researchers in CMU registering the patent, petty patent, and copyright.’ (PPA3) ‘CMU has [a] policy to researchers for using a number of patents to claim their academic position.’ (UPE2)

5.2.9 Cell 9: Creating start-ups and promoting the commercialisation of research results

The findings from participants showed CMU supported researchers to start their own business. Also, it supported on-park firms to set up their business and help them to spin off from the STeP programme. 'A process of benefits' that the firms received from participating in STeP programmes was also observed. It started with the firms participating in the STeP programme, then STeP and CMU helped some firms to coordinate with other organisations (such as funding agencies). After that, CMU researchers engaged in R&D activities to develop new products and transfer knowledge to firms. Consequently, firms received the benefits in the commercialisation phase (some firms received services related to IP management and obtained additional information from CMU researchers after spin-off; see also Appendix 2 for the full structure of Impact Process, emphasising cell 9, obtained via the data analysis from phases 1 and 2). On-park firms and university–science park executives were also asked to rate the STeP programme and CMU as 100% or less than 100% in terms of supporting exploitation and commercialisation. The results showed that all the on-park firms interviewed rated the programme at 100%, believing that CMU researchers can help them develop new products and that they will see success in terms of commercialisation after spin-off. However, two university–science park executives rated the programme less than 100% due to their observation that some firms did not commercialise their new products. The example quotes illustrating this role are presented in Table 5.9.

TABLE 5.9: SUMMARY OF FINDINGS FROM PHASE 1 (CELL 9)

The role/s of the university (exploitation and commercialisation roles)	Theme/s	Illustrative quote/s
Cell 9 - Start-ups Creation (Incubator) - Promoting the Commercialisation of Research Results (University + Science Park)	The firms start business operations directly from the university and rely on the services of STeP	'As I am an ex-researcher in CMU, I conduct the research by myself and use my research results in my own business. I conduct R&D activities to serve the other firms as well. So, I think I do the research collaboration with STeP and CMU by means of the consultancy project, which I signed the contract to participate in the programme of STeP and they helped me to coordinate with [the] university, the other organisations and the on-park firms in order to incubate my business, look for the research funding, solve the problems, as well as provide the advice on marketing for my business. I have received research funding for my project from the public organisation, which is the National Research Council of Thailand (NRCT).' (OPF2) 'In sum, [I] participated in the programme, I received additional funding from [a] government agency and got [the] knowledge to do the business. In particular, B2G (Business to Government) is the coordination with government. Hence, the links with STeP, which is the public organisation, and CMU, which is the famous university, can make me easily connect with other firms and organisations.' (OPF2) 'I will get the new channels to commercialise my new products by launching at [an] international fair that [was] recommended by STeP and CMU. Also, [the] IP team from STeP and the experts from [the] Technology Licensing Office (TLO) in CMU will help me to manage the IP. I will still keep [in] contact with the experts to exchange information.' (OPF2)
	Firms will spin-off from the STeP programme	'I believed that [the] CMU researcher can help me [with] developing my new product. Then, I will spin-off and can sell it in Thailand.' (OPF1)
	On-park firms and university–science park executives were asked to rate the STeP programme and CMU as 100% or less than 100% in terms of supporting the exploitation and commercialisation.	'I rated 100% because the programme of STeP that collaborated with CMU can help firms to develop new products and they can commercialise new products in the real market. Obviously, spin-off firms can adopt new knowledge that they get from the programme into their real-life business. This reason can confirm the success of [the] programme in this role of [the] university.' (UPE1) 'I observed that some spin-off firms did not commercialise their new products from the programme in the market. I rated [the project success at] 80%.' (UPE2)

5.2.10 Section summary

This section has presented the findings from phase 1, which provides a broad overview of the roles and relationships of CMU based on the conceptual framework developed through the systematic literature review presented in this thesis. Broadly, this indicates that the framework is useful in framing the activities of the university, but also that there may be important differences in emphasis for the activities contained in individual cells for the specific peripheral region developing-economy context of Northern Thailand. The analysis in Chapter 6 will explore these in more detail when analysing RQ2. Phase 1 also began to identify four interactive processes (described in more detail in Appendix 2, where Phase 1 identified the emphasis of the process which gives it its name and phase 2 identifies the precise sequencing of cells within the process). To examine the specific interactive innovation processes that occur between the actors in the RIS–university–science park nexus within actual innovation projects (also previously identified as a gap in the literature), phase 2 of this thesis therefore presents 12 case studies of more and less successful innovation projects that the CMU researchers undertook with spin-off firms from the STeP programmes. The framework, is also, however, of relevance when examining the individual project cases. The next section therefore illustrates the basic findings from phase 2 (case studies), prior to the in-depth analysis contained in Chapter 6.

5.3 Phase 2 Case studies

This section presents the findings from the 12 case studies of more successful and less successful projects that the CMU researchers undertook with spin-off firms from the STeP programmes. They portray the roles of the university, the relationships between researchers and firms in the actual innovation process as well as illustrate the factors affecting the roles of the university within a peripheral region developing-economy context to commercialise research results through the science park.

The case studies' innovation processes were conducted between 2014 and 2017. Eleven cases were from the IRTC programme and only one case was from the incubation programme. Both programmes offered funding from SPA, which is a unit under MOST, to the on-park firms. The IRTC programme allowed researchers from CMU to conduct the R&D activities for firms and the time span was approximately 12 to 14 months. As for the incubation programme, it aims to focus on entrepreneurial development. Only one case study was from the incubation programme because the firm needed to obtain laboratory testing to confirm the quality of the product. As a result, the researcher participated in this case to undertake laboratory testing for the firm. The time span of the incubation programme is approximately three years per project.

Each case begins with a brief introduction of the project's background, including the characteristics of the spin-off firm and the motivation to start the project. This is followed by a discussion of the process and the relationships within the pre-development phase, the development activities phase, and the commercialisation phase based on the innovation pipeline.

5.3.1 Case 1: The development of traditional Thai instant coffee to enhance commercial competitiveness and exporting

Background

This project was started in 2014 and finished in 2015. It was a project conducted between the CMU researcher and a large coffee roaster in Chiang Mai. All coffee beans were bought from local growers. The interviewed firm found that 70% of the coffee beans were being used to produce its instant coffee, while 30% were too small in size and would normally be thrown away. To avoid discarding these small coffee beans, they were roasted and ground for brewing 'traditional Thai coffee'. The firm received good feedback from customers; however, the brewing method was difficult because customers needed to put the ground coffee in a cotton bag filter and then steep it in boiling water. Therefore, the firm decided to produce it in the form of instant coffee.

The firm used the existing production process for manufacturing traditional Thai instant coffee. However, the properties of the instant coffee, including colour, taste and smell, were not similar to 'fresh' traditional Thai coffee. The firm lacked the knowledge to adjust these properties and needed to improve the production process. The following quote illustrates how this case study emerged:

> *'My business brought coffee beans from the growers. I found that 70% of coffee beans can be used in normal production, but 30% were small [in] size. I would like to add value to them. So, I let my staff roasted the small coffee beans and made the traditional Thai coffee… I received good feedback from the customers. However, the brewing method was so hard for them. As a result, I decided to produce traditional Thai instant coffee… Then, I found that the colour, the taste, and the smell of instant coffee were not similar to the 'fresh' one. I lacked the knowledge to adjust these properties.'* (A1)

Pre-development phase

The firm had previous experience with the researcher from the academic services of the Faculty of Agro-Industry, CMU. They used this to undertake a project related to the 'Khao Hom coffee' in which the researcher blended Thai jasmine rice with the coffee to create a new, uniquely fragranced coffee product. After finishing this project, they still kept in touch.

The process that could benefit the firm from the 'strong' relationship with the researcher was as follows:

1. The firm could consult the researcher. As Researcher A stated, *'The firm did not know how to adjust the colour, the taste, and the smell of the instant coffee to be similar to the fresh traditional Thai coffee. So, the firm consulted me about these issues.'*
2. The researcher then provided information about the STeP programme for starting the new project. When the firm decided to participate, the researcher wrote the proposal and sent it to STeP. According to Researcher A: *'I recommended the firm to participate in the STeP programme because STeP offered additional funding for firms. Then, I wrote the proposal and discussed it with the firm. We finally sent the proposal to STeP.'*

Lastly, STeP staff contacted the firm to evaluate the intention and the feasibility of the proposal.

Development activities phase

STeP accepted the firm into the IRTC programme. The contract was signed and the firm received the additional funding. After that, the researcher set up a formal meeting with the firm to discuss and share the idea. The project, finally, aimed to develop the instant coffee that had the same taste, smell and colour of the fresh traditional Thai coffee. Also, it aimed to develop the production process.

At this stage, the researcher searched for additional knowledge to modify the firm's equipment for use in the experiments by building 'a regional network' with the firm's manufacturing equipment supplier: *'I contacted the firm's supplier directly to share the knowledge and let the supplier prepare the equipment for use in the R&D activity'* (Researcher A). Therefore, four main actors participated in this project, including the researcher, the firm, the firm's supplier and, finally, STeP staff who coordinated between the firm, researcher and STeP.

The nature of this project was related to basic research, applied research and process development. First, the researcher came to the firm's factory to collect samples of 'fresh' traditional Thai coffee. Then, the R&D activity started with basic research, measuring the total soluble solids (TSS) of samples of brewed traditional Thai coffee. After that, process development based on the applied research was started, aiming to compare and find which method could be used to reproduce the taste, colour and smell which was (nearly) that of fresh traditional Thai coffee. The researcher dehydrated the samples of instant coffee by using two different methods: freeze-drying and a spray-dryer granulator (Figure 5.1). The researcher found that using a spray-dryer granulator made the instant coffee properties similar to those of fresh traditional Thai coffee and the production cost was also lower than the alternative. The TSS of the instant coffee from using the spray-dryer granulator was also equal to the TSS from the original samples. Therefore, the researcher suggested using the spray-dryer granulator in the production process of the new product.

FIGURE 5.1 PICTURE OF THE INSTANT COFFEE PRODUCED BY USING THE FREEZE-DRYER (LEFT) AND SPRAY-DRYER GRANULATOR (RIGHT)

Source: *The Annual Report of the Northern Science Park (NSP)*, 2015

When conducting the experiments described above, the researcher requested that laboratory assistants from the Faculty of Agro-Industry, CMU, who were master's degree students, prepare the materials required. The chemical laboratory, pilot plant and food processing laboratory of the Faculty of Agro-Industry were used by the researcher. The firm also used the spray dryer in CMU, with the researcher making instant coffee the first time. Some of the R&D activities were performed in the firm's factory. However, the firm did not participate in all experiments because it was seen as the duty of the researcher, as A1 explained, *'I did not participate in all experiments. I just shared my idea to the researcher in the early stage of the project; then I attended in some experiments that the researcher suggested me to participate [in]. In this project, the researcher had the role to conduct all [the] experiments to serve me.'*

Throughout the programme, the researcher contacted the involved parties by using telephone calls, emails and the LINE (mobile application) group between the firm, the researcher and the firm's R&D staff. The researcher presented the project's progress and demonstrated the experimental method to the firm in the meetings that, sometimes, the firm's R&D staff participated in. Furthermore, the knowledge from the R&D activities and the basic knowledge in food science, including the production process, the method to adjust the taste, the smell, and the colour to be similar to the traditional Thai coffee, the packaging, the spray drying technique and the sensory evaluation, were transferred to the firm via the meetings, LINE, and telephone calls. The researcher also visited the firm's factory to transfer knowledge. Additionally, the firm received project-relevant knowledge of new technology that they never had previously from the CMU seminars. The following quote illustrates what the firm received from attending the STeP programme:

'It can be concluded that I received the knowledge, the new product, and the process development from attending the STeP programme.' (A1)

Commercialisation phase

After spinning off from the programme, the firm preferred to keep all research data 'secret'. Hence, the firm did not apply for a patent. Moreover, the firm used the original equipment manufacturer (OEM) that had the spray dryer to manufacture the new product. The traditional Thai instant coffee was commercialised in both Thailand and China. Commercialising the new product has helped develop the regional economy, as A1 stated: *'I received the income from the added value product. Further, my business can develop Northern Thailand economy because my business brought all size coffee beans straight from the growers. The growers in Northern Thailand received the earnings. So, I do the sustainable business.'*

Even though the firm spun-off from the programme, the firm still kept in touch with the researcher and STeP staff by using LINE, email and telephone calls. Because of the personal relationships, the firm received benefits as *'We still kept in touch…the researcher gave me the information related to the packaging'* (A1) and STeP staff invited the firm to show the new product at the innovation fairs:

> *'I conducted research to develop the new product of firm. After the firm spin-off, STeP staff contacted the firm to present the new product in the innovation fairs. So, this is the process that STeP and CMU promoted the technological change. By showing the product in the fairs, it was the way that STeP presented technological*

change from this project to others and the firm could expand the market.' (Researcher A)

In sum, both the firm and researcher rated the outcome of this project to be 100% because of the following benefits:

1. The firm benefited from both the new product and the process development.
2. The new product has been successfully commercialised in both Thailand and China.
3. The new product could develop the regional economy.
4. STeP invited the firm to present the new product at the innovation fairs. As a result, the firm could receive new customers.

5.3.2 Case 2: The probiotic fermented sausage (E-sarn sausage)

Background

This project started in 2014 and ended in 2015. It was a project between a researcher from CMU's Science and Technology Research Institute (STRI) and the SME. The interviewed firm was an entrepreneur of Vietnamese restaurants in Northern Thailand and had the idea to add the 'E-sarn sausage' or a fermented sausage, that originated from North-Eastern Thailand, as a new menu item. Normally, the E-sarn sausage is made from minced pork mixed with salt, garlic, pepper, sugar and coriander seed. Then, rice and lard are added and kneaded with the pork mixture. After that, the pork mixture is put into an intestines wrapper as sausages and they are fermented to be sour. Before eating them, the fermented sausages are fried or grilled. The firm produced the E-sarn sausages and found that the sourness of each sausage was different and not stable. Therefore, the firm needed to improve the production process, aiming to control the sourness of the E-sarn sausage.

Pre-development phase

The firm knew the researcher before attending the STeP programme because they had collaborated during a prior project related to a Vietnamese grilled pork sausage. They still kept in touch after finishing that project.

There were three stages where the firm benefited from the personal relationship with the researcher:

1. The firm consulted the researcher. According to A2: *'As I found the sourness of E-sarn sausages cannot be controlled, I consulted this problem with the researcher.'*
2. The researcher analysed the firm's production process and provided information about the STeP programme. According to Researcher B: '*I found that the firm produced the E-sarn sausages in Bangkok and used the time for transportation from Bangkok to Chiang Mai as the fermentation period. So, it was not the standard production. Moreover, the firm used the natural bacteria for fermentation. As a*

result, the sourness from fermentation of the bacteria in the sausages was different. I suggested the firm to improve the production process and I would look for the strain of bacteria to control the sourness. Also, I provided the information of STeP programme. I recommended the firm to participate because I had the connection with STeP and it provided the additional funding for [the] firm.'

3. The firm decided to participate in the STeP programme. Then, the researcher wrote the proposal: '*I wrote the proposal for the firm because I knew the scope of the research. Then, I had a meeting with [the] firm to talk about and discuss the details of our new project. After that, we sent the proposal to STeP'* (Researcher B).

Finally, STeP staff contacted the firm to evaluate the project's feasibility.

Development activities phase

STeP accepted the firm into the IRTC programme. The firm signed the contract and received the additional funding. Then, the researcher set up a formal meeting with the firm to describe the methods to solve the firm's problem and allow the firm to share its ideas. This project, therefore, aimed to study the firm's production process and improve it by finding the optimum amount of probiotic bacteria in the production process and finding the optimum conditions for the fermentation of the E-sarn sausage. Three main parties were involved in the project: the researcher, the firm and STeP staff who coordinated between the firm, researcher and STeP.

Before starting the R&D activities, the researcher searched for additional knowledge related to probiotic bacteria in academic journals to support the R&D activities. Then, the firm brought production staff to the researcher to demonstrate the existing method used in the production of the E-sarn sausages. Based on the basic research, the researcher examined and studied the risks of contamination in the production process for the firm by dividing the production process into three stages, including the preparation of ingredients, the mixing and the fermentation. The researcher found that all three stages presented contamination risks. As a result, the researcher suggested a method of sterilisation to the firm. Then, the process development based on the applied research was commenced, aiming to find the optimum amount of probiotic bacteria to use in the production process and to find the optimum conditions for the fermentation of the E-sarn sausage. The researcher extracted the probiotic bacteria from the firms' E-sarn sausage and cultured it for use in R&D activities. During this stage, the researcher started making the sausages by preparing the ingredients (Figure 5.2), mixing the ingredients and adding different amounts of probiotic bacteria (Figure 5.3). After that, the mixture was put into an intestine wrapper to make the sausages (Figure 5.4).

FIGURE 5.2 PICTURE OF THE INGREDIENTS FOR MAKING E-SARN SAUSAGES

Source: *The Annual Report of the Northern Science Park (NSP)*, 2015

FIGURE 5.3 PICTURE OF MIXING THE INGREDIENTS AND ADDING THE DIFFERENT AMOUNT OF PROBIOTIC BACTERIA

Source: The Annual Report of the Northern Science Park (NSP), 2015

FIGURE 5.4 PICTURE OF ADDING THE MIXTURE INTO AN INTESTINES WRAPPER (LEFT) AND PICTURE OF THE UNFERMENTED E-SARN SAUSAGES (RIGHT)

Source: *The Annual Report of the Northern Science Park (NSP)*, 2015

The researcher made unfermented E-sarn sausages with different amounts of probiotic bacteria. To find the optimum amount of probiotic bacteria and the optimum conditions, the researcher fermented the sausages in different temperatures over different time periods (Figure 5.5). Finally, the researcher produced an E-sarn sausage with the 'proper' level of sourness (Figure 5.6) and found that the optimum amount of probiotic bacteria should be 4 log cfu/g and the optimum conditions for production should be fermentation at 30°C for around 2 days or fermentation at 4°C for more than 10 days.

FIGURE 5.5 PICTURE OF SAUSAGES FERMENTATION

Source: *The Annual Report of the Northern Science Park (NSP)*, 2015

FIGURE 5.6 PICTURE OF THE FINISHED E-SARN SAUSAGE WITH PROPER SOURNESS

Source: *The Annual Report of the Northern Science Park (NSP)*, 2015

To undertake the R&D activities, the researcher used laboratory equipment, such as the incubator for incubating the probiotic bacteria, laboratory sterilisation equipment, agar plates and an inoculation loop for streaking, and so on, in CMU's Faculty of Agro-Industry. The assistants from CMU's Faculty of Agriculture were requested to help the researcher control the production process. However, the firm did not participate in all R&D activities.

Throughout the development activities phase, the involved parties used telephone calls and email to communicate. Also, the researcher set up formal meetings with the firm to present the project's progress. Additionally, the researcher transferred the knowledge related to the advantages of probiotic bacteria to the firm via the meetings and telephone calls. The firm also received project-relevant knowledge of new technology from the seminars set up by CMU. In sum, the firm obtained an improved production process, an improved product and knowledge from attending the STeP programme. According to A2: *'I got the process development for E-sarn sausage that had the sourness as I expected. Moreover, I got the knowledge, which I never knew before, from both researcher and STeP.'*

Commercialisation phase

After spinning off from the programme, the firm did not register the patent because the registration process was complicated and was perceived to waste time. The firm and the researcher still kept in touch. When the firm had questions about the product or production process, the researcher usually provided the information to the firm, as stated by Researcher B: *'After spin-off from the programme, I contacted the firm by using telephone calls for answering the firm questions.'* The firm did not keep in contact with STeP. According to A2: '*I did not keep in touch with STeP because the project has been finished already.'* As the firm did not keep in contact, STeP did not present technological changes from this project at the innovation fairs.

Because the firm was concerned with the bacterial strain and preferred to buy it instead of preparing it, as well as needed to test the amount of probiotic bacteria for fermentation in the whole production process, the firm has still not commercialised the E-sarn sausage. Nevertheless, the firm aimed to launch it during 2018, believing that the sausage will make a profit due to its lower production costs.

Lastly, both the firm and researcher rated the outcome of this project to be less than 100% due to the following reasons.

1. While the firm received the process development for the E-sarn sausage that had the sourness the firm expected, the time for the project was too short and some of the R&D activities needed a lot of time.
2. As a result, the researcher did not have the time to find the right amount of probiotic bacteria and the conditions for the whole production process. According to A2: *'I produced E-sarn sausages following the amount of probiotic bacteria and the conditions that the researcher recommended. I found that it worked for the small production. However, the researcher did not test the amount of probiotic bacteria and the conditions for the whole production because the time duration of STeP programme ran out.'*

5.3.3 Case 3: 'Kombucha' the snack from a by-product of fermented tea production

Background

This project was started in 2014 and ended in 2015. It was a project between a CMU researcher and a large company that commercialised the fermented tea beverage, 'Kombucha'. Because the 'by-product' from the production of Kombucha was observed as normally being thrown away as tea waste, the interviewed firm wanted instead to add value by making it into a new product. According to A3: *'I did the business about the Kombucha that was the beverage consumed in China for a long time. The Kombucha was made from sugared black or green tea with yeasts and bacteria that produced organic acids, vitamins and antioxidants. As a result, it had health benefits. For example, it could lower cholesterol, blood pressure, and inflammation. Because I found a lot of by-product or tea waste from the production of Kombucha, I would like to add-value by making it as the new product.'*

Although the firm knew the Kombucha and its by-product contained a lot of DSL (D-Saccharic acid-1,4 lactone), glucuronic acid, organic acid, vitamin and free radicals which benefit human health, the firm had no idea how to make the by-product valuable for commercialisation. The firm, therefore, looked to the public sector programme that offered a researcher to help the firm create the new product from tea waste.

Pre-development phase

The firm did not have previous experience with CMU or STeP. Instead, the firm received information about STeP and its programmes from the internet. The firm decided to apply to the IRTC programme because, as A3 indicated: *'I made [the] decision to participate [in] the STeP programme because it offered the funding for on-park firms and, also, provided the researcher who was the expert to help firms create new products. So, I sent a proposal to STeP applying to the programme.'* After sending the proposal to STeP, three stages occurred:

1. STeP staff contacted the firm to visit the firm company and evaluate the intention.
2. The staff then matched the firm's proposal with a potential researcher from CMU: *'STeP staff contacted me to participate in this project because of my expertise in product development'* (Researcher G).
3. The firm discussed the proposal with the potential researcher from CMU.

Finally, the firm accepted the potential researcher to be the researcher of this project.

Development activities phase

STeP accepted the firm into the IRTC programme. The firm signed the contract and received the additional funding. Then, the researcher set up a formal meeting with the firm to discuss and provide ideas for developing the new product: *'I had a formal meeting with the firm for discussing the proposal to find what the firm would like to do with the tea waste. Finally, I pointed out the way to develop tea waste as the new product by making it as the healthy snack that should be crispy from baking or fry-up at high temperature'* (Researcher G). The firm agreed with this idea, so the researcher finalised the proposal. This project, therefore, aimed to produce a healthy snack from tea waste, develop the production process and design the packaging.

Three main parties were involved in the project. The first were the staff members from STeP who coordinated between STeP, the firm and researcher. The second one was the firm who sometimes sent staff to learn how to conduct the research with the researcher. The last one was the researcher who undertook all the R&D activities. In addition, this project was a collaboration between STeP, CMU and CMU's Food Innovation and Packaging Centre (FIN) that the researcher was a member of.

To start the R&D activities, the firm brought the tea waste from the production of Kombucha to the researcher (Figure 5.7). The researcher did not search for additional knowledge to undertake the R&D activities because making tea waste into a healthy snack had never been researched before. Instead, the researcher commenced by using applied research to find which type of tea waste from the firm's production would be the best for making a healthy snack. After considering the tea waste carefully, the researcher found that the rough grinding tea waste that separated the leaf stalk was the best form from which to make the snack (Figure 5.8).

FIGURE 5.7 PICTURE OF THE TEA WASTE FROM PRODUCTION OF KOMBUCHA

Source: *The Annual Report of the Northern Science Park (NSP)*, 2015

FIGURE 5.8 PICTURE OF THE ROUGH GRINDING TEA WASTE THAT SEPARATED THE LEAF STALK

Source: *The Annual Report of the Northern Science Park (NSP)*, 2015

After that, the product development started; it aimed to improve the healthy snack's production process. The researcher found that the best shape of the snack would be in the form of dried seaweed slices. So, the tea waste was mixed with fish gelatine and gum arabic. Then, the researcher steamed and baked it in the laboratory ovens. As a result, the researcher produced a healthy snack that was crispy (Figure 5.9). Also, the researcher designed the packaging as the box for the new product.

FIGURE 5.9 PICTURE OF THE HEALTHY SNACK

Source: *The Annual Report of the Northern Science Park (NSP)*, 2015

Lastly, the researcher used basic research to test the moisture content and the water activity (a_w) of the new product. The researcher found that the new product was safe and could resist the growth of pathogenic microorganisms because the water activity was within the standard range.

The researcher used equipment and a laboratory oven from the CMU's Faculty of Agro-Industry to undertake this project. The laboratory assistants from CMU's Faculty of Agro-Industry and FIN were requested to help the researcher undertake the R&D activities. The firm also participated in some parts of the R&D activities.

The involved parties were contacted using telephone calls and email. The researcher also presented the project's progress to the firm in meetings. Throughout the programme, the researcher transferred the technique of snack forming, the research results and the methods to use the chemicals to the firm in meetings and by using emails and telephone calls. The researcher demonstrated the method that was used in the R&D activities to the firm and, sometimes, to the firm's staff. As the firm participated in CMU seminars, the firm received project-relevant knowledge of new technology.

In sum, the firm obtained the new product prototype, a production process, packaging, and knowledge from attending the STeP programme, as indicated by A3: *'I received the new* *innovative product, new process to produce the healthy snack, and the suitable packaging. Additionally, I got the knowledge from the researcher. The knowledge was useful, making me know the production process of my new product.'*

Commercialisation phase

After spinning off from the programme, the research results were not registered via a patent due to the firm not observing any benefit from registering them. The firm did not keep in touch with the researcher because the project was finished. There was no missing out on potential benefits as *'The firm did not have a problem with the new product and no additional information that I should give to the firm after spin-off. So, we did not need to keep the contact'* (Researcher G). Nevertheless, the firm still kept in touch with STeP staff: *'I still contact with STeP staff who usually sent me the invitation to present the prototype of my new product in the innovation fairs'* (A3). The firm, therefore, showed the prototype at the innovation fairs set up by STeP, allowing STeP to present technological change from this project to others.

Recently, the firm is looking for an OEM that has similar equipment to that the researcher used in the R&D activities, as well as at a larger scale for production. Therefore, the new product has not been launched. However, the firm believed that the new product would generate a lot of earnings due to it being distinctive and could be commercialised in both Thailand and Japan. According to A3: *'My business usually commercialises the products in Japan. Because Japanese people are interested in and accustomed to the tea products, I have planned to commercialise this new product in Japan. Also, I have planned to commercialise it in Thailand, especially targeting at the general customers and the customers who like the healthy product. So, I think the new product could make me receive earnings of more than one million baht per year.'*

In conclusion, both the firm and researcher rated the outcome of this project to be 100% because of the following benefits.

1. The tea waste added-value to become a new product.
2. The firm obtained the new product, production process, and the packaging.

3. STeP sent the prototype of the new product to be a contestant in the innovation fairs and let the firm attend the fairs to present it. Hence, the firm could expand its market: *'the people can observe my new product and I could receive the new customers'* (A3).
4. The new product was distinctive. It could attract all people who love a healthy snack.

5.3.4 Case 4: The production of paper mâché from rice straw for an SME

Background

This project was started in 2015 and finished in 2016. It was a collaboration project between the CMU researcher and the SME. The interviewed firm is in a business related to the production of paper from rice straw. Normally, the rice straw is a useless by-product from agriculture. The firm had the idea of producing a 'unique' paper mâché made from 'organic' rice straw. However, it had no machinery capability. The production process was conducted by hand, was time-consuming and produced variable results. According to A4: *'My business had a lot of organic rice straw. I would like to add value by transforming it to be the paper mâché. Normally, I and my employees produced the paper mâché by hand and the production process wasted time. I lacked the machines to help me produce the paper mâché.'*

Pre-development phase

The firm knew the researcher before attending the STeP programme because they had previously participated in a project related to the production of paper from rice straw. The prior project was in a National Science and Technology Development Agency (NSTDA) programme and the researcher acted as the consultant. After finishing this project, they still kept in touch.

Through the following three stages, the firm collaborated and received benefits from keeping in contact with the researcher:

1. The firm could consult the researcher about the problems and the needs to start the new project.
2. The firm got the information about the STeP programme from the researcher. According to Researcher C, *'I suggested the firm to attend the STeP programme because it offered the additional funding.'*

3. The firm decided to participate in the programme. Then, the researcher wrote the proposal, discussed it with the firm and sent it to STeP.

Finally, STeP staff contacted the firm to evaluate the project's feasibility.

Development activities phase

STeP accepted the firm in the IRTC programme. The firm signed the contract and received the additional funding to develop the machines for production. Only STeP, the firm and CMU participated in this project. The researcher and firm had a formal meeting to finalise the requirements of the project, which aimed to develop the moulding machine, the hot air blower and improve the production process of paper mâché. The firm also brought materials from the factory to the researcher for use in the experiments.

First, the machinery development commenced. The researcher searched for current methods to produce the packaging paper used for eggs from the internet and applied this knowledge together with the concept of a vacuum cleaner to create the moulding machine (Figure 5.10). As for the hot air blower, the researcher developed it from simple materials by using a 1000 watt heater as the heat source and establishing fans to dissipate the hot air (Figure 5.11). Secondly, the process and product development started. It aimed to test the developed machines and improve the surface of the paper mâché to be smooth. The researcher used the moulding machine that combined with the reservoir tank to form the paper mâché. There were 100 pieces per 3 hours that the moulding machine can form into paper mâché and the surface was smoother than forming it by hand. After that, all the paper mâché pieces were put into the hot air blower. As a result, they were dried faster (Figure 5.12).

FIGURE 5.10 PICTURE OF THE MOULDING MACHINE

Source: *The Annual Report of the Northern Science Park (NSP)*, 2016

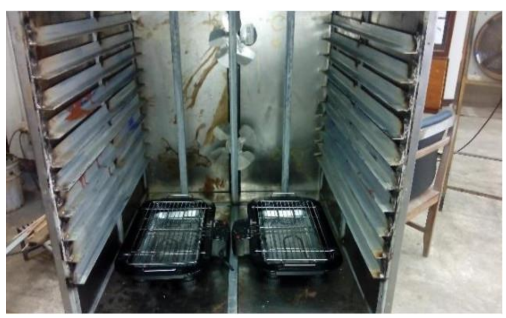


FIGURE 5.11 PICTURE OF THE HOT AIR BLOWER

Source: *The Annual Report of the Northern Science Park (NSP)*, 2016

FIGURE 5.12 PICTURE OF THE DRIED PAPER MÂCHÉ

Source: *The Annual Report of the Northern Science Park (NSP)*, 2016

Throughout the development activities phase, the firm did not participate in all R&D activities. The researcher worked with an assistant from CMU and they used the mechanical factory in the Faculty of Science to undertake the R&D activities.

The involved parties used telephone calls, LINE and email to communicate. The researcher also set up meetings to provide updates on the project progress. Further, the researcher acted as 'the knowledge intermediary' by transferring knowledge of the production process, the technique of fibre milling, and the method to develop the machines to the firm. Also, the researcher provided project-relevant knowledge of new technology on materials science to the firm. In sum, the firm benefited from attending the STeP programme, as A4 demonstrated: '*Finally, I got the developed machines, an improved production process, the improved product, and the knowledge for the production from the researcher.'*

Commercialisation phase

The firm was a spin-off from the programme. Even though STeP offered expertise to consult in developing a patent application, the firm did not register the patent because it preferred to focus on the production of the improved product. The paper mâché was commercialised in Thailand and Malaysia. Further, the firm contributed to the regional economy due to using rice straw to make the paper mâché. As a result, the rice straw created added value and the farmers received additional income.

At this stage, the firm still kept in touch with both the researcher and STeP staff by using telephone calls, LINE and email. The firm benefited from these personal relationships: *'I kept in touch with the researcher and he still provided the additional information related to production process'* (A4) and *'STeP staff contacted the firm to present the improved product in the innovation fairs'* (Researcher C). By showing the product at the innovation fairs, STeP presented technological change from this project to others and the firm also gained new customers. Finally, both the firm and researcher rated the outcome of this project to be 100% because of the following benefits:

1. The firm received the machines developed during the project. As stated by A4: *'My business had the problem about the production capacity. After spin-off, I got the developed machines that can control the quality of my product and save time for the production.'*
2. The moulding machine was created using a vacuum cleaner. Hence, the firm did not need to buy any expensive equipment.
3. The firm commercialised the product in Thailand and Malaysia.
4. STeP contacted the firm to present the improved product at the innovation fairs. Also, the firm could expand its market.

5.3.5 Case 5: A prototype from the by-product of a solid surface and the chemical formula development for the production of a new solid surface and its coating

Background

The project was started in 2016 and ended in 2017. It was a project between the CMU researcher and a large company. The interviewed firm imported a solid surface from South Korea and Spain to produce countertops, sinks, shower pans, and so on, for commercialisation in the Thai market. However, 10% of the solid surface ended up as scraps produced from processing. The solid surface scraps were seen as a useless by-product and were normally discarded. Even though the firm knew the solid surface scraps contained 70% of $Al(OH)_3$ which has a fire-retardant property, the firm had no idea how to add value to them. Hence, the firm looked for a researcher who could develop a new product from the scraps.

Pre-development phase

The firm observed the researcher's research portfolio at the Thailand Tech Show in Bangkok. The firm then contacted the researcher directly. The firm sent the samples of the solid surface scraps to the researcher. After that, they had an informal meeting in Chiang Mai.

Through the following three stages, the firm collaborated and benefited from meeting with the researcher:

1. The researcher gave the idea of producing a surface coating, which contained the fire retardant property, and would be waterproof and scratch-proof, by crushing the solid surface scraps and mixing them with Acrylic Emulsion. Moreover, the surface coating could be reformed as a new solid surface because it can solidify at room temperature. Due to the production of a new solid surface using the Acrylic Emulsion that dissolved in water, the firm did not need to use resin or its solvent

which were dangerous. So, the two new products, the surface coating and the new solid surface, were safe and had outstanding benefits.

2. The firm agreed with the researcher's idea. Also, the researcher provided the firm with information about the STeP programme in order to start the project.
3. The firm decided to participate in the programme. As a result, the researcher and the firm wrote the proposal and sent it to STeP.

Finally, STeP staff contacted the firm to evaluate the project's feasibility.

Development activities phase

STeP accepted the firm into the IRTC programme. The firm signed the contract and received the additional funding. Then, the researcher set up a formal meeting with the firm to share their ideas and discuss the new products. This project, finally, was the production of the surface coating and the new solid surface from the solid surface by-product. It aimed to find the optimum mixture of $Al(OH)_3$ and Acrylic Emulsion for the production of the new products.

At this stage, the researcher contacted the chemical supplier and let the supplier prepare different concentrations of the Acrylic Emulsion for use in the experiment. There were four main parties participating in this project: the firm, the researcher, the supplier, and STeP staff. Moreover, the researcher organised a chemist, who was a lecturer at CMU, to be the consultant and the project was undertaken in the Faculty of Science, CMU.

Although the researcher did not search for additional knowledge to undertake this project, the researcher applied current knowledge to develop the new products and production process. The nature of this project was related to applied research; the R&D activities started with the study of the initiator effect. The researcher crushed the solid surface scraps that contained $Al(OH)_3$ and mixed them with the Acrylic Emulsion to make the mixture. Then, the researcher compared the results of the moulding between the two mixtures, including the mixture comprising the $Al(OH)_3$ and Acrylic Emulsion without adding the initiator, and the mixture comprising $Al(OH)_3$, Acrylic Emulsion and the initiator. The results showed that adding the initiator would make the $Al(OH)_3$ and Acrylic Emulsion mixture better for moulding. After that, the researcher undertook the process and product development by finding the optimum balance mixture to produce the surface coating and the new solid surface. The researcher mixed different concentrations of $Al(OH)_3$ with Acrylic Emulsion and the initiator. Finally, the researcher produced a prototype of the surface coating (Figure 5.13) and produced a prototype of the new solid surface by moulding the optimum mixture (Figure 5.14).

FIGURE 5.13 PICTURE OF THE PROTOTYPE OF THE SURFACE COATING

Source: *The Annual Report of the Northern Science Park (NSP)*, 2017

FIGURE 5.14 PICTURE OF THE PROTOTYPE OF THE NEW SOLID SURFACE

Source: *The Annual Report of the Northern Science Park (NSP)*, 2017

Throughout the development activities phase, the involved parties used email and telephone calls to communicate. The researcher presented project progress updates to the firm via the meetings. Also, the researcher transferred knowledge of the chemical formula development used to produce the surface coating and the new solid surface to the firm in meetings and by using email and telephone calls. Due to the project being built upon the knowledge of materials science and chemistry, the firm did not receive project-relevant knowledge of new technology, as stated by A5: *'I did not receive project-relevant knowledge of new technology from the researcher or STeP. It was because the project combined more than one research area.'*

In sum, the firm obtained the prototypes, process and product development, and production knowledge from attending the STeP programme. However, the development of the new products was not finished due to the researcher needing to undertake additional R&D activities. The firm, therefore, only obtained the prototypes at the end of the programme's duration.

Commercialisation phase

The firm spun-off from the STeP programme. Research results were not registered as patents because the firm preferred to keep all data 'secret'. Even though the new products were not commercialised, the firm believed that this project could develop the economy and cause wealth creation. According to A5: *'I think this project could develop the Thai economy by reducing the import of the solid surface from the international countries. Normally, I imported the solid surface for processing and selling in Thailand. I received the total revenue [of] around 30-40%. I could receive 100% as the by-product from my business was added value.'*

The firm and researcher still kept in touch by using email and telephone calls. Hence, the firm could benefit from its 'strong' personal relationship with the researcher in terms of the researcher providing information to the firm about the next project aiming to finish the new products. As new products were not finished and the firm did not keep in contact with STeP staff, STeP did not present the technological change from this project to others at the innovation fairs. According to Researcher C: *'STeP did not present [the] technological change from our project to the others because the final products have not been finished.*

We still need to do the R&D activities and the firm is looking for the other programmes of the public sector to do our next project.'

In sum, both the firm and researcher rated the outcome of this project to be approximately 95% because of the following benefits and drawbacks:

1. The firm gained the prototypes, process and product development, and knowledge for the new production process.
2. The new products could be commercialised in both Thailand and international countries. As stated by Researcher C: *'If the products were finished, the firm could commercialise them in Thailand and international countries because the products were safe, eco-friendly and distinctive.'*
3. The researcher, however, needed to undertake additional R&D activities to finish the new products.
4. Because the new products were not finished, the firm needed to find other public sector programmes to undertake the next part of the project. According to A5: *'I got only the prototypes at the end of the STeP programme. Recently, I am looking for the other programmes of the public sector to do the next project and make the prototypes to be commercialised.'*

5.3.6 Case 6: The development of an eco-friendly oven for drying chilli

Background

This project was set up in 2016 and finished in 2017. It was a project between the CMU researcher and the SME. The interviewed firm commercialised cayenne pepper. In the production process, the firm used an open-air oven to dry the hot chilli peppers, then transformed them into cayenne pepper. A 'problem' occurred, however, because the oven released the chilli smell and smoke, disturbing local people. It was, therefore, an environmental problem for the area where the firm's factory was located. The following quote outlined the firm's problem: *'I used my existing oven to produce the cayenne pepper. It left the heavy chilli smell and smoke, bothering the people around my factory'* (A6). The firm, therefore, needed to get rid of the chilli smell and smoke.

Pre-development phase

The firm knew the researcher before attending the STeP programme. They had undertaken a prior project related to the use of the hot air oven for drying longan. After finished that project, they still kept in touch.

Through the following three stages, the firm collaborated and received benefits from keeping in contact with the researcher:

1. The firm told the researcher about the problem.
2. As the firm received the information about STeP from PR (Public Relations), the firm discussed it with the researcher. According to A6: *'I used to attend the seminar of the Federation of Thai Industries Chiang Mai Chapter and I saw the advertisement for STeP that had funding for entrepreneurs. So, I told the researcher that I preferred to participate [in] the IRTC programme for doing our new project.'*
3. The researcher agreed with the firm. Then, the firm wrote the proposal to participate in the STeP programme.

Finally, STeP staff contacted the firm to evaluate the feasibility of the project.

Development activities phase

STeP accepted the firm into the IRTC programme. The firm signed the contract and received additional funding equivalent to approximately 40% of all expenses. Then, the researcher came to observe the firm's problem at the factory. After that, the researcher set up a formal meeting with the firm to share ideas to find a solution to the problem and finalise the proposal. Eventually this project aimed to develop a new 'eco-friendly oven' that had a deodorising system. Three main parties participated, including the firm, the researcher and STeP staff.

To develop the new oven, the researcher did not search for additional knowledge. The researcher used their experience in mechanical engineering and current knowledge to undertake R&D activities. During this stage, the new oven was designed and developed from the researcher's knowledge of hot air ovens for drying longan (from the prior project), combined with the system of the crematory. Then, the researcher tested the deodorising system by passing the air with chilli smell through the burning point in the oven at a high temperature. As a result, the chilli smell was reduced and, at burning point, the heat could be reused as the heat source for the next round. The researcher finished the development of the eco-friendly oven. Lastly, the oven was set up in the firm's factory (Figure 5.15).

FIGURE 5.15 PICTURE OF THE ECO-FRIENDLY OVEN WITH THE DEODORISING SYSTEM

Source: *The Annual Report of the Northern Science Park (NSP)*, 2017

To undertake this project, the researcher used computers and space in CMU's Faculty of Engineering. The assistants from the same Faculty were requested to help the researcher develop the oven. However, the firm did not participate in all R&D activities.

Throughout the development activities phase, the involved parties contacted each other by using email and telephone calls. The researcher set up meetings with the firm to report on the project's progress. What is more, the researcher came to the firm's factory to guide the firm's use of the developed oven. The researcher transferred the knowledge of the developed oven, the methods to make crushed chilli, and the chilli milling methods to the firm, as stated by A6: *'The knowledge was transferred through the meetings, emails, and telephone calls. It was useful because I never knew it before.'* Also, the firm received project-relevant knowledge of the new technology from the researcher. According to Researcher D: *'I gave the knowledge of new technology on the chilli cleaning machine and chilli roasting machine to the firm.'*

In sum, the firm received the developed machine to produce the product and additional knowledge from attending the STeP programme.

Commercialisation phase

The firm was then a spin-off from the STeP programme. As the firm signed a contract with STeP, research results from this project were not registered as a patent and the authority belonged to CMU. Moreover, the firm and researcher still kept in touch. As a result, the researcher provided information about the chilli cleaning machine and chilli roasting machine to the firm. Because of this information, the firm decided to undertake the next project with the researcher. The firm did not keep in touch with STeP staff due to this project being finalised. So, STeP did not contact the firm to show the developed oven at the innovation fairs.

The firm used the developed oven in its production and found that it can also help the firm save production costs. According to A6: *'As the oven used firewood that can be found in the local area, I did not need to use and buy the liquid propane gas that was expensive. It lowered my production cost. The oven enhanced the quality of the production as well.'*

Finally, both the firm and researcher rated the outcome of this project to be 100% because of the following reasons:

1. The developed machine can be used in the production process and it reduced the chilli smell and smoke that were the firm's main problem: *'I think this project was very successful because the new oven can help the firm solve the environmental problem'* (Researcher D).
2. The developed oven can save production time and costs.
3. The developed oven was eco-friendly.

5.3.7 Case 7: The Modular Farm mobile application for the agro-industry

Background

This project was set up in 2016 and finished in 2017. It was a project between the CMU researcher and the SME. The interviewed firm owned the 'Modular Farm' which was an indoor farming system that can plant out-off-season fruit and vegetables in a climate controlled by the technology. As the firm was an IT business, it had the idea to develop a mobile application controlling the Modular Farm system. To do this, it needed to combine and apply knowledge of agriculture and informatics. The firm, therefore, looked for an academic who could develop the modular farm mobile application. According to A7: *'I did the business about IT and I owned the Modular Farm. So, I had the idea to develop the mobile application that can help the people controlling the temperature, light, humidity, and so on, in the Modular Farm. However, I lacked the knowledge to develop it. As a result, I searched for the experts who can do it for me.'*

Pre-development phase

The firm had experience with the researcher before attending the STeP programme. They collaborated on a prior project related to the development of hardware for the Modular Farm. After that, they still kept in touch. Through the following three stages, the firm collaborated and received benefits from keeping in contact with the researcher:

1. The firm consulted the researcher to start a new project to develop a mobile application.
2. As the new project was large, the firm needed to have additional funding. The researcher, hence, provided the firm with information about the STeP programme. According to Researcher E: *'I gave information about the STeP programme to the firm. Because STeP offered funding up to 50% of all expenses, the firm decided to participate.'*
3. The firm agreed to participate in the IRTC programme. Therefore, the firm and researcher sent the proposal to STeP.

Finally, STeP staff contacted the firm to evaluate the project's feasibility.

Development activities phase

STeP accepted the firm into the IRTC programme. The firm signed the contract and received additional funding of approximately 40% of all expenses. After that, the researcher set up a formal meeting with the firm to finalise the aim of this project, which was the development of a mobile application to control the system of the Modular Farm. Due to the project being large and needing to combine more than one research area, six main parties participated: the firm, STeP staff, the researcher who developed the mobile application, the expert in hydroponic farms, the expert in the growing of vegetables by using a light-emitting diode, and the expert in censors. The researcher contacted all experts directly to engage them in some parts of the project. Therefore, it was a collaboration between STeP, the CMU's College of Arts, Media and Technology (CAMT) (in which the researcher was the member), the other universities in Northern Thailand, and the private sector.

To start the R&D activities, the researcher came to observe the firm's Modular Farm in order to collect data to develop the mobile application. Then, the researcher searched academic papers to gain additional knowledge related to the Modular Farm system. As the nature of this project was related to mobile application development, the researcher commenced with the development of the system architecture. The Modular Farm mobile application was developed to be an application for Android mobile devices, especially for smart phones and tablets, and it worked with the web service of the Modular Farm system. Hence, the Modular Farm mobile application can show data from the Modular Farm database and can control the temperature, light, humidity, and so on in the Modular Farm. After that, the researcher built the application workflow. The Modular Farm mobile application therefore had functions starting with the application log-in, registration of new users, and managing data of the Modular Farm (Figure 5.16).

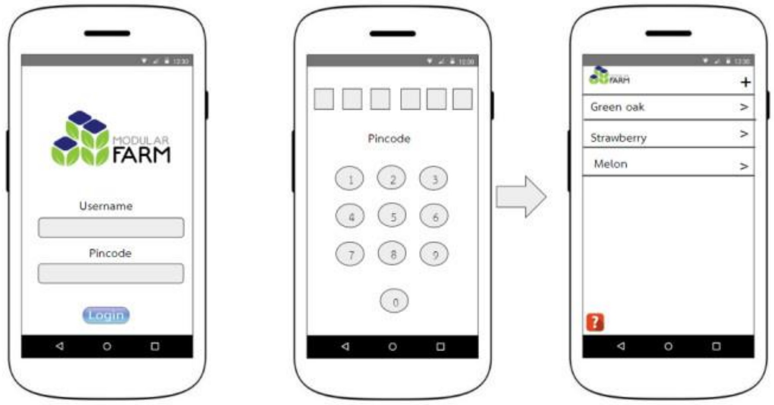


FIGURE 5.16 PICTURE OF THE MOBILE APPLICATION

Source: *The Annual Report of the Northern Science Park (NSP)*, 2017

Throughout the R&D activities described above, the researcher engaged experts from Maejo University and an expert from Mae Fah Luang University in Northern Thailand as consultants. However, the firm did not participate in any R&D activities. The researcher used their own computer to do the project, as indicated by Researcher E: *'I did not use any infrastructure of CMU. I used my own computer and the firm brought the IT materials for me. Because the nature of this project did not relate to the experiment in the laboratory, I did not need to use any CMU infrastructure.'*

The involved parties used telephone calls, email and LINE to communicate. The researcher set up formal meetings with the firm and the experts to present the project's progress and share the idea to develop the mobile application. Also, the researcher transferred knowledge to the firm regarding the methods used in the mobile application via meetings, LINE and email. Moreover, the firm received project-relevant knowledge of new technology in mobile applications and IT software from seminars that were set up by CMU.

However, the Modular Farm mobile application was around 40% complete at the end of the STeP programme. According to Researcher E: *'Because the mobile application connected with the system of Modular Farm that was in the stage of development, it made the testing of mobile application longer than expected. Recently, the mobile application* *itself still needs to be improved. So, we will do and finish it in our next project.'* In sum, the firm got only the prototype of the Modular Farm mobile application and the knowledge from attending the STeP programme.

Commercialisation phase

The firm spun off from the STeP programme. The research result from this project was not registered as a patent due to the Modular Farm mobile application not being finished. The firm and researcher still kept in touch by using LINE and telephone calls. As a result, the researcher provided the firm with information regarding funding for their next project. The firm did not keep in contact with STeP staff because the mobile application was not finished and it preferred to do the next project in the programme with another organisation. STeP did not, therefore, contact the firm to show the Modular Farm mobile application at the innovation fairs.

Even though the Modular Farm mobile application was not finished, the firm believed that it could be commercialised because of the following benefits:

1. The Modular Farm mobile application could help people plant fruit and vegetables more conveniently.
2. The application could help people to grow out-off-season vegetables and fruit in a controlled environment.

Therefore, the firm had a plan to commercialise the Modular Farm mobile application with future customers in Dubai *'because the environment in Dubai was limited to grow some types of fruit and vegetables'* (A7). In addition, the Modular Farm mobile application could contribute to both the firm's and the Thai economy.

In conclusion, the firm and researcher rated the outcome of this project to be less than 100% because of the following reasons:

1. The firm received a prototype that can be used with the Modular Farm. According to A7: *'Even though the prototype did not work in full options, I think this project*

was successful in terms of the prototype can be used together with the Modular Farm when the researcher tested it.'

2. The duration of the STeP programme, however, was too short: '*I think this project was successful but not 100% because the mobile application was finished around 40%. Umm ... it was the large project and needed to combine more than one knowledge background, I think ... the duration of STeP programme was too short for this project'* (Researcher E).
3. The firm and researcher needed to do the next project. According to Researcher E: *'I and the firm will start the next project that I will do the R&D activities continuously from this one.'*

5.3.8 Case 8: Yogurt-covered macadamia nuts

Background

This project was set up in 2016 and finished in 2017. It was a project between the CMU researcher and the SME. The interviewed firm was involved in organic farming and macadamia nuts were one of the firm's products. As the firm would like to create new products, it had the idea of making yogurt-covered macadamia nuts. However, the firm lacked the knowledge to produce them. Hence, the firm looked for a public sector programme to undertake the project to develop yogurt-covered macadamia nuts. According to A8: *'I did the business about the organic farming. The macadamia nuts were the product from my farm. I would like to get a new product, which should be a healthy snack, for my business. So, I had [the] idea to make the yogurt-covered macadamia nuts.'*

Pre-development phase

This project was a 'follow-on' from a prior one. The firm had worked on a prior project with the researcher in the AS programme with CMU's Faculty of Agro-Industry. Due to it being a free programme with a short duration, the prior project was only 50% finished. The following quote provides an overview of the prior project:

> *'The project aimed to develop the yogurt-covered macadamia nuts. The firm brought the example of the yogurt-covered cashew nuts to me. I saw the example and found that the cashew nuts were covered with the white chocolate that was mixed with the yogurt powder. As the firm would like to make the new product to be [a] healthy snack, I told the firm that it was not totally healthy snack because the covered surface was made from white chocolate which contained lipid. However, the firm still wanted to do it. So, I needed to make the new white chocolate containing milk, sugar, and cocoa butter, which was good lipid. Further, I needed to use the chocolate-making equipment that was expensive. Because the firm received only small funding, I used the other machine instead of it. At the end of [the] prior project, I found that the texture of the chocolate was not fine'* (Researcher F)

After that, the firm and researcher still kept in touch. The firm also looked for a public sector programme to undertake the next project and finish the development of the yogurt-covered macadamia nuts. Through the following two stages, the firm collaborated with the researcher to participate in the STeP programme:

1. The firm received the STeP information and consulted the researcher: *'I attended* the *seminar of Thailand Food Valley and received the information about STeP. I preferred to participate in the STeP programme because it offered funding. So, I consulted the researcher to participate in the programme'* (A8).
2. The researcher agreed to participate in the STeP programme with the firm. Then, the firm wrote the proposal and sent it to STeP.

Finally, STeP staff contacted the firm to evaluate the project's feasibility.

Development activities phase

STeP accepted the firm into the IRTC programme; the contract was then signed. As the researcher requested the machine or the 'wet grinder', STeP offered funding to buy it. After that, the researcher had a meeting with the firm to share the ideas for improving the new product. This project, therefore, aimed to make the texture of covered yogurt, or white chocolate, to be softer and develop the covered surface to be stable at high temperatures. Four main parties participated: STeP staff, the firm, the researcher and the cocoa butter supplier. In addition, the firm brought macadamia nuts from the farm to the researcher for use in R&D activities.

At this stage, the researcher searched for additional knowledge on chocolate technology by reading books and looking at YouTube to learn methods for making white chocolate. Then, the researcher contacted the supplier directly to prepare cocoa butter for use in the R&D activities. First, the researcher started with applied research to find the optimum amount of the main ingredients, including the amount of cocoa butter, sugar and yogurt powder, and to find the optimum time for refining the mixture to be softer. The researcher found that the optimum amount of ingredients should be 30% cocoa butter, 30% sugar and 10% yogurt powder. After that, the researcher mixed the ingredients and used the wet grinder to refine the mixture (Figure 5.17). The result showed that the optimum time for refining the mixture should be 24 hours. Finally, the researcher made the texture of the covered yogurt softer, as the firm requested (Figure 5.18). Secondly, product development commenced. The researcher added the glazing agent as the second covered surface of the yogurt-covered macadamia nuts. As a result, the firm's new product would not melt at high temperatures.

FIGURE 5.17 PICTURE OF THE WET GRINDER

Source: *The Annual Report of the Northern Science Park (NSP)*, 2017

FIGURE 5.18 PICTURE OF THE YOGURT COVERED MACADAMIA NUT

Source: *The Annual Report of the Northern Science Park (NSP)*, 2017

Throughout the R&D activities described above, the researcher requested assistants from CMU's Faculty of Agro-Industry to help the researcher prepare the materials. The firm did not participate in any experiment. In terms of using CMU's infrastructure, the researcher performed all the R&D activities in the Faculty of Agro-Industry to test the texture of chocolate and prepare the materials, while the firm used CMU's library to obtain additional knowledge on chocolate technology.

The involved parties used email and telephone calls to communicate. The researcher also set up meetings to provide project progress updates and train the firm and its R&D staff to produce the new product. The researcher transferred knowledge related to chocolate technology and the production process of yogurt-covered macadamia nuts to the firm in meetings and via telephone calls. Because the firm was not based in Chiang Mai, however, it did not receive project-relevant knowledge of new technology from seminars that were set up by CMU. In sum, the firm received new product and knowledge from attending the STeP programme: *'I got my new product, or the yogurt-covered macadamia nuts, and the knowledge for production from the researcher'* (A8).

Commercialisation phase

The firm spun-off from the STeP programme. The research result from this project was not registered as a patent as the firm believed the registration process to be complicated. The firm and researcher still kept in touch by using telephone calls. As a result, the firm was able to contact the researcher when it had questions about new products and the researcher also provided information to answer the firm's questions. However, the firm did not keep in contact with STeP staff because the project had ended. STeP, therefore, did not contact the firm to show the new product at the innovation fairs and did not present the technological change from this project to others.

The firm used the wet grinder received from attending the STeP programme to manufacture the new product. The yogurt-covered macadamia nuts were commercialised in the Thai market and contributed to the firm's wealth creation: *'This new product can be commercialised in the market because it was distinctive. I received additional earnings and* *good feedback from the customers. Moreover, I have planned to expand the market not only for the people who love the healthy snack but also for all people'* (A8). Lastly, both the firm and researcher rated the outcome of this project to be 100% because of the following reasons:

1. The firm benefited from the new product as *'the firm got [a] new product and it can be commercialised in the market'* (Researcher F).
2. The macadamia nuts were added value and the firm can apply the knowledge from this project to develop other new products. According to A8: *'My normal product was added value to be [a] new product. Moreover, I can apply the knowledge from this project with the other materials I have. For example, I developed other new products including the yogurt-covered dried lychee and the yogurt-covered longan.'*

5.3.9 Case 9: A mulberry powdered drink mix

Background

This project was set up in 2016 and finished in 2017. It was a project between the CMU researcher and the SME. The interviewed firm undertook mulberry farming and commercialised products made with mulberries. Normally, mulberries have a short shelf-life and are harvested only in March to April. The firm had an idea to produce a new product, the 'mulberry powdered drink mix', in order to extend the shelf-life of mulberries. The following quote indicates how this project emerged: *'I did mulberry farming and commercialised the product from mulberries such as the mulberry tea, fresh mulberries, mulberry jam, and the mulberry juice. As mulberries have a short shelf-life, I would like to extend it by developing a new product or the mulberry powdered drink mix'* (A9). Because the firm lacked knowledge in product development, the firm looked for an organisation from the public sector to provide a researcher to help the firm create the new product.

Pre-development phase

The firm knew the researcher before attending the STeP programme. First of all, the firm attended training run by the provincial industry office that collaborated with CMU's FIN. The FIN staff recommended the researcher who worked in the FIN to the firm. Then, the firm contacted the researcher directly.

Through the following three stages, the firm collaborated with the researcher to participate in the STeP programme:

1. The firm consulted with the researcher about the idea to produce the mulberry powdered drink mix.
2. The researcher then provided information about the STeP programme: *'the researcher gave me the information about the STeP programme and told me that STeP had additional funding for on-park firms'* (A9).

3. The firm decided to participate in the IRTC programme. As a result, the researcher and firm wrote the proposal and sent it to STeP.

Finally, STeP staff contacted the firm to evaluate the project's feasibility.

Development activities phase

STeP accepted the firm into the IRTC programme. The firm signed the contract and received the additional funding. After that, the researcher had a formal meeting with the firm to discuss the concept of the new product: '*we share the idea about the new product, such as it should be produced in the form of powder, it should be dissolved in cold or normal temperature, and it should have long shelf-life'* (Researcher G). Finally, this project aimed to develop the mulberry powdered drink mix and design the packaging. Three main parties were involved in this project: the firm, the researcher and STeP staff.

To start the R&D activities, the researcher came to the firm's farm to collect fresh mulberries (Figure 5.19). After that, the researcher started by using basic research to study the fresh mulberries in terms of physical and chemical properties. The researcher conducted a pH level test (a measure of how acidic/basic water is), solubility test, water activities (a_w) measurement, moisture content test, and the TSS measurement. As a result, the researcher found that the mulberry juice from the farm had a pH value around 4 and had a TSS of 11.8°Brix (Brix=the sugar content of an aqueous solution).

FIGURE 5.19 PICTURE OF THE FRESH MULBERRIES

Source: *The Annual Report of the Northern Science Park (NSP)*, 2017

The researcher then used applied research to find the optimum amount of ingredients, such as mulberry juice, water, Maltodextrin and sucrose, to produce the mulberry powdered drink mix. Moreover, the researcher searched academic papers to gain additional knowledge of the spray drying process. By mixing different amounts of ingredients and using the spray dryer to dehydrate the mixture, the researcher obtained four prototypes of the mulberry powdered drink mix that met with the standards of the Thai Industrial Standard Institute (Figure 5.20). Lastly, the researcher designed the packaging by using aluminium foil to retain the chemical properties of the powder (Figure 5.21).

FIGURE 5.20 PICTURE OF FOUR PROTOTYPES

Source: *The Annual Report of the Northern Science Park (NSP)*, 2017

FIGURE 5.21 PICTURE OF THE PACKAGING

Source: *The Annual Report of the Northern Science Park (NSP)*, 2017

Throughout the above described R&D activities, the researcher used a spray dryer in CMU's Faculty of Agro-Industry to make the mulberry powder; laboratory assistants from the same Faculty were requested to help the researcher. However, the firm did not participate in any R&D activities.

The involved parties used LINE, email and telephone calls to communicate. The researcher set up meetings with the firm to provide project progress reports. Also, the researcher transferred knowledge of the spray drying technique, research results and nutrition facts to the firm via meetings, LINE and emails. As the firm was not located in Chiang Mai, it did not receive any project-relevant knowledge of the new technology from the CMU seminars. In sum, the firm received the prototypes and production knowledge from attending the STeP programme. According to A9: *'I got four prototypes of mulberry powdered drink mix. Further, I got knowledge for production as well as packaging from participating [in] the STeP programme.'*

Commercialisation phase

The firm then spun-off from the STeP programme. The research result from this project was not registered as a patent because the registration process seemed complicated for the firm. The firm did not contact the researcher and STeP staff because the project was finished. There was no missing out on potential benefits from not keeping in touch with the researcher as *'I did not need to keep contact with the firm because I transferred all knowledge of this project to the firm already. Also, the firm did not have any problem about the new product'* (Researcher G). As the firm did not keep in contact with STeP staff, the firm did not show the new product at the innovation fairs that were set up by STeP to present the technological changes from the projects of spin-off firms.

Even though the new product has still not been commercialised due to the firm looking for an OEM, the firm believed that it could contribute to wealth creation. According to A9: *'Recently, I am looking for the OEM because I do not have the factory. I think that when my new product is ready to commercialise in Thailand, I will receive additional earnings. Moreover, I do not need to discard the mulberries that nearly expire because the knowledge from this project can help me transform them to the powder with a long shelf-life. Finally, I could sell my new product in the longer period.'* Lastly, both the firm and researcher rated the outcome of this project to be less than 100% because of the following reasons:

1. The firm received the new product prototypes and packaging from attending the STeP programme.
2. The new product, however, was still not commercialised as *'I think my project was successful but not 100% because the product has not been launched*' (A9).
3. The new product was distinctive and could be commercialised both in Thailand and the international countries. According to Researcher G: '*I think my new product would be interested by the foreigner because mulberry is [a] Thai local fruit and it would attract the foreigner who wants to try something new'.*

5.3.10 Case 10: The Riceberry macaron with coconut filling

Background

This project was set up in 2016 and finished in 2017. It was a project between the CMU researcher and the SME. The interviewed firm was in business related to confectionery and wanted to bring local materials and develop them into a new product. As the 'Riceberry' was grown primarily in Northern Thailand, the firm had the idea of producing a new product from it. However, the firm lacked knowledge in product development. The firm, therefore, looked for a public sector programme that could help the firm transform the Riceberries into a new product. The following quote demonstrates how this project emerged: *'I did business about the confectionery. I would like to bring the local materials to develop as [a] new product. Then, I observed a lot of Riceberry in my local area. I think it would be better if I could add value to rice and develop it to be [a] new product'* (A10).

Pre-development phase

The firm had no previous experience with CMU or STeP. However, the firm received information about the STeP programme from a leaflet at an innovation fair. The firm then decided to attend the programme and sent its proposal to STeP. After that, three steps occurred:

1. STeP staff contacted the firm to visit the firm's business and evaluate the intention.
2. STeP staff then matched the firm's proposal with a potential researcher in CMU: *'the staff recommended the potential researcher of this project to me'* (A10).
3. The potential researcher had a meeting with the firm to discuss the proposal. According to Researcher G: *'I discussed the proposal with the firm to find what the firm would like to do with the Riceberry. At first, the firm did not specify the kind of new product [they wanted]. So, we did [some] brainstorming and decided to do the Riceberry macaron with coconut filling.'*

Finally, the firm agreed to make a Riceberry macaron with coconut filling and accepted the potential researcher to be the researcher of this project.

Development activities phase

STeP accepted the firm in the IRTC programme. The firm signed the contract and received the additional funding. After that, the researcher had a formal meeting with the firm to summarise the activities for developing the new product. Hence, this project aimed to develop the Riceberry macaron with coconut filling and its production process. Three main parties were involved in the project, including the firm, the researcher and STeP staff. In addition, the firm brought Riceberries to the researcher for use in the R&D activities.

To undertake this project, the researcher searched for additional knowledge related to macaron ingredients from macaron cookbooks. The researcher then started R&D activities by using applied research to find the proper amount of Riceberry powder by using the mill machine and sifter. Then, the researcher prepared different concentrations of Methocel solution to study the Riceberry macaron foaming by mixing them with Riceberry powder and beating until foamy (Figure 5.22).

FIGURE 5.22 PICTURE OF MAKING THE RICEBERRY MACARON FOAMING

Source: *The Annual Report of the Northern Science Park (NSP)*, 2017

After that, the researcher studied the baking of the macaron by finding the optimum ingredient mixture between the macaron foam, icing sugar, stabilising agent and dried coconut, and finding the optimum temperature and time for baking. The researcher also developed the coconut filling from shortening, dried coconut and coconut sugar. Finally, the development of the Riceberry macaron with coconut filling was complete (Figure 5.23).

FIGURE 5.23 PICTURE OF THE RICEBERRY MACARON WITH COCONUT FILLING
Source: *The Annual Report of the Northern Science Park (NSP)*, 2017

Throughout the above described R&D activities, the researcher used the forming machine in CMU's FIN. The laboratory assistants from the FIN were requested to help the researcher. However, the firm did not participate in any R&D activities.

The involved parties used email, LINE and telephone calls to communicate. The researcher set up meetings with the firm to present project progress reports and transfer the knowledge and techniques for making the macarons. However, the firm did not receive project-relevant knowledge of new technology from the CMU seminars because it was not located in Chiang Mai. In conclusion, the firm received the prototype and production knowledge. According to A10: *'I got new [the] product or the prototype of [the] Riceberry macaron with coconut filling that had [a] good taste. Moreover, I got knowledge for production from attending the STeP programme.'*

Commercialisation phase

The firm spun-off from the STeP programme. Even though STeP offered experts to consult on IP management, the firm did not register the patent for the research results. However, the firm would like to consider it later. The firm did not keep in touch with the researcher because the firm had received the new product. There was no missing out on potential benefits from not keeping in contact with the researcher: *'I transferred all knowledge to the firm. So, we did not keep contact and I did not need to provide any information to the firm. Moreover, the product of [the] firm did not have [any] problem[s]'* (Researcher G). The firm also did not keep in touch with STeP staff. As a result, STeP did not contact the firm to show the prototype at the innovation fairs.

Because the firm would like to develop the packaging for the macarons, the firm has still not commercialised the new product. Nevertheless, the firm believed that the new product could generate wealth creation when launched in the future. According to A10: *'I [have] still not commercialise[d] my new product because I would like to develop its packaging by myself. Personally, I think this new product would make me receive additional earnings because it is a healthy product. Normally, the macaron is a sweet meringue-based confection and made with egg white, icing sugar and almond. My new product does not contain the same ingredients as the normal one. Further, it could be commercialised in Thailand and international countries.'* In sum, both the firm and researcher rated the outcome of this project to be around 80% because of the following reasons:

1. The firm received a new product and it was distinctive: '*The macaron itself was distinctive, [has a] good taste and [a] long shelf-life. Moreover, it was a healthy product'* (Researcher G).
2. The firm can also use other types of rice instead of using the Riceberry to produce the macaron.
3. The new product, however, still needs to have the proper packaging.

5.3.11 Case 11: 'Easy cup' – the packaging for keeping the quality of Lanna Khao Soi ice cream toppings

Background

This project was set up in 2016 and finished in 2017. It was a project between the CMU researcher and the SME. The interviewed firm owned an ice cream shop in Chiang Mai and had a signature ice cream that was called the 'Lanna Khao Soi ice cream'. As the signature ice cream toppings contained fried noodles and breadsticks, the firm wanted to design new packaging that would keep the quality of its toppings. The following quote indicates how this project emerged: *'I would like to design the packaging for my signature ice cream that contained fried noodles and breadsticks as toppings. So, the packaging should be designed to keep the quality of [the] toppings, and the taste of [the] toppings should be the same after freezing'* (A11). However, the firm lacked knowledge in product development and packaging design. The firm, finally, looked for a public sector programme that offered researcher help to the firm in designing the ice cream packaging.

Pre-development phase

The firm had no previous experience with CMU or STeP. However, the firm received information about the STeP programme from an advertisement on the internet. Because STeP collaborated with CMU, which had an expert to help the firm design the packaging, the firm decided to participate in the STeP programme. The firm, therefore, wrote the proposal and sent it to STeP. After that, three steps occurred:

1. STeP staff contacted the firm to visit the firm's business and evaluate the intention.
2. STeP staff matched the firm proposal with a potential researcher in CMU: *'STeP contacted me to participate [in] this project because my expertise lay in packaging design'* (Researcher G).
3. The firm discussed the proposal with the potential researcher of this project. According to Researcher G: *'I discussed the proposal with the firm to find what the*

firm would like to do. I gave idea[s] to the firm and estimated the costs of this project.'

The firm agreed with the potential researcher's idea. Finally, the firm accepted the potential researcher to be the project researcher.

Development activities phase

STeP accepted the firm into the IRTC programme. The firm signed the contract and received the additional funding. After that, the researcher had a formal meeting with the firm to share their ideas about packaging. This project aimed to design the packaging and test the taste of the ice cream and its toppings after freezing it within the developed packaging. Five main parties were involved in this project: STeP staff, the firm, the researcher, experts on sensory evaluation who tested the taste of the ice cream and its toppings, and the supplier that prepared the packaging materials. The researcher contacted both the experts on sensory evaluation and the supplier directly to recruit them to participate in this project.

Before starting the R&D activities, the researcher searched articles to gain additional knowledge of ice cream technology. The researcher commenced designing the packaging by considering the background of the firm, which was the SME. As such, the researcher tried to use local materials and modified the materials from the supplier to develop the packaging. Moreover, the packaging should be easy to use. Because the toppings of the Lanna Khao Soi ice cream are baked products that can change taste at room temperature and after freezing, the researcher designed the packaging to be a cup with a dome cap that can house the ice cream toppings between the cup and dome cap was plastic, to which the spoon was attached (Figure 5.24).

FIGURE 5.24 PICTURE OF THE DEVELOPED PACKAGING

Source: *The Annual Report of the Northern Science Park (NSP)*, 2017

The researcher then used basic research to study the changed properties of the ice cream toppings in the developed packaging after freezing. To do this, the researcher tested the moisture content, the water activity (a_w) and the determination of thiobarbituric acid reactive substances in ice cream toppings. The researcher found that the packaging could keep the quality of the ice cream toppings because the testing results were in the range of standard industrial manufacturing. Lastly, the researcher set up a formal meeting between the firm and the experts in sensory evaluation to test and discuss the taste of the ice cream and its toppings after freezing.

To undertake the above described R&D activities, the laboratory assistants from CMU's FIN were requested to help the researcher. However, the firm did not participate in some of the R&D activities. In terms of the CMU infrastructure used, the researcher used the incubators in CMU's Faculty of Agro-Industry and FIN to test the shelf-life of the ice cream toppings. Moreover, the firm also used CMU's intranet and online library to search for information on improving the ice cream flavour.

Throughout the development activities phase, the involved parties kept in contact by using LINE, telephone calls and email. The researcher had meetings with the firm to present project progress updates and transfer their knowledge on ice cream technology. Also, the researcher explained all the R&D processes, provided the testing results and showed the developed packaging to the firm in meetings. Because the firm had no time to attend the

CMU seminars, the firm did not receive project-relevant knowledge of the new technology. In sum, the firm received the developed packaging and knowledge for the product from attending the STeP programme. According to A11: *'I got [the] packaging and knowledge for my product before spin[ning] off from the programme.'*

Commercialisation phase

The firm then spun-off from the STeP programme. Even though STeP provided training on IP and offered experts to transfer knowledge on the methods to register the patent, petty patent and trademark, the firm did not apply for the patent for the research results. However, the firm planned to register it in the future. Because the project had been finalised, the firm did not keep in touch with the researcher. There was no missing out on potential benefits from not keeping contact with the researcher because, as stated by Researcher G *'I transferred all knowledge to the firm. As a result, we did not need to keep contact. Also, I did not provide any information to [the] firm because [the] project has been finished and [the] packaging did not have any problem[s].'* The firm still keeps in touch with STeP staff by using LINE and telephone calls. Therefore, STeP staff contacted the firm to show the developed packaging at innovation fairs, allowing STeP to present technological changes from spin-off firm projects.

The ice cream and its developed packaging can be commercialised for both local people and foreign tourists in Chiang Mai. The firm also sent the ice cream with the developed packaging to sell in other, main, provinces of Thailand and received great feedback. Hence, this project contributed to the firm's wealth creation. According to Researcher G: *'The firm got the developed packaging to keep the quality of ice cream and its toppings. Recently, the firm sent the ice cream to sell in the other regions of Thailand. So, the firm can extend the market and receive additional earnings.'* In conclusion, both the firm and researcher rated the outcome of this project to be 100% because of the following reasons:

1. The firm benefited from the developed packaging.
2. The firm can commercialise the product with the developed packaging in the Thai market.

3. The firm sent the product with developed packaging as a contestant and received awards from Thailand and international countries. According to A11: *'I sent the ice cream with developed packaging as a contestant in the national innovation contest of the NIA [National Innovation Agency]. As a result, I received the award winning in the category of best packaging. I also received other national awards from my packaging and [I am] the representative of Thailand in international contests. For example, I won the award in Malaysia and was the representative of Asia to attend the innovation contest in Toronto, Canada.'*

5.3.12 Case 12 Production of sexed semen by using cytotoxic sperm technology for the dairy industry

Background

This was the only case from STeP's incubation programme that a CMU researcher participated in. The project started in 2014 and was between the SME, STeP and the CMU researcher. The head of the interviewed firm was a former lecturer from CMU's Faculty of Agriculture. While working as a lecturer, the firm received funding from the National Research Council of Thailand to conduct research to develop new technology that was called 'the sperm cytotoxic'.

The sperm cytotoxic is *'the production of the sexed semen containing the sperm with the X chromosome used for the artificial insemination'* (A12). By using this technology, female birth rates of approximately 70% among dairy cattle were achieved, as required by the dairy industry. The firm used the sperm cytotoxic technology to undertake the business of producing frozen sexed semen as the product and the artificial insemination for the farmers in Thailand. When the frozen sexed semen was produced, it was necessary to assess the quality and the percentage of female dairy cattle births. Because the CMU's policy did not allow retired lecturers to access or use CMU infrastructure, the firm could not perform the laboratory testing for the product.

Pre-development phase

The firm knew of the STeP programme as the head of the firm was a former CMU lecturer. Due to the firm lacking the knowledge to undertake the business, the firm decided to participate in the STeP programme. According to A12: *'I decided to participate in the STeP programme because I did not have the knowledge to do the business. STeP had the incubation programme for the start-ups. Hence, I applied to participate in this programme.'*

Interestingly, this firm had a very 'strong' personal relationship with the researcher, as stated by researcher H: *'I knew the firm very well. I used to be the advisee of the firm. Umm... the [head of the] firm was my master's degree advisor. We did the experiments* *together for a long time'*. More recently, the researcher had been a lecturer in CMU's Faculty of Agriculture and still kept in touch with the firm even after the firm head's retirement from CMU.

Development activities phase

STeP accepted the firm in the incubation programme. The firm signed the contract and STeP provided the expert to help the firm register the company. Additionally, STeP coordinated the firm with the NSTDA and let the firm participate in the Leader in Innovation Fellowship programme. As a result, the firm received funding and went to the UK to attend business and innovation training.

Due to the firm participating in the STeP programme, STeP coordinated with the CMU to allow the researcher to undertake the laboratory testing for the firm as one part of the incubation programme. Then, the firm had a formal meeting with the researcher. According to Researcher H: *'I met the firm in the meeting. The firm let me assess the quality of the frozen sexed semen and check the percentage in the birth of the female dairy cattle.'* Further, STeP connected the firm with the Department of Livestock Development and the National Research Council of Thailand that provided the additional funding for this project.

In this part of the incubation programme, four main parties were involved. The first party comprised STeP staff who coordinated between the firm, researcher and STeP. The second was the researcher. The third was the lecturer, from another university in Northern Thailand, who helped the researcher test the firm's product. The last party was the firm. In addition, the parties kept in contact through telephone calls, LINE and meetings.

The nature of this project was related to basic research in biotechnology, immunology and molecular biology. Before starting the laboratory testing, the researcher searched academic papers to find suitable methods for testing the firm's product. As a result, the researcher found the protocol and set the trial conditions for the experiments. The researcher then used the DNA (deoxyribonucleic acid) technique, the flow cytometer technique and computer-assisted semen analysis to check the percentage in the birth of female dairy cattle that would approximately be 70%. By using all these techniques, the researcher could estimate the percentage and assess the quality of the firm's product.

While conducting the above experiments, the lecturer from Maejo University was contacted directly by the researcher to help and participate in the testing. The researcher used the laboratory equipment, such as the computer-assisted semen analysis, flow cytometer, laminar flow, freezer, Real-time PCR, and so on, in CMU's Faculty of Agriculture to perform the experiments. As the firm did not participate in any experiments, the researcher transferred the knowledge related to the methods for testing the product and the laboratory results to the firm during the meetings and by using LINE and telephone calls. However, the firm did not receive project-relevant knowledge of new technology because this project combined more than one research area. In sum, the firm received the laboratory testing service, business incubation, additional funding, and connections with the other organisations attending the STeP programme.

Commercialisation phase

The firm is still involved in the incubation programme. The firm only finished the product testing part of the project. If the firm needs to test the product again in the future, the researcher can assist the firm because they still keep in touch by using the same channels of communication and the firm is still in the STeP programme. Even through STeP offered experts to help the firm register the patent, the firm did not register it because the firm preferred to keep all research results 'secret'.

While still in the incubation programme, the firm received benefits as STeP coordinated with the experts from different organisations to provide information about business law, marketing and the new technology. As demonstrated by A12: *'The information was provided through the seminars and training. It was useful making me receive the additional knowledge.'* Also, STeP let the firm show the product at the innovation fairs to present the technological change from this project to others.

The firm commercialised the tested product to customers in Thailand and it believed that this project contributed to the Thai and regional economy, as A12 stated: *'I can establish* *my business and can commercialise my product in Thailand. I received the income from my developed technology. Further, my product was distinctive. It had [a] high percentage in the birth of female cattle. If Thai farmers can reduce the import of sexed semen from international countries, the farmers can save more. Additionally, I plan to commercialise the product in Asian countries, such as Vietnam, Lao and India in the future.'*

In conclusion, both the firm and researcher rated the outcome of this project to be 100% because of the following benefits:

1. The firm received the business knowledge.
2. The firm received funding from STeP to present the product in Singapore, Poland, USA, China, UK, France, Germany, and so on. As a result, the firm received awards from Thailand and international countries. According to A12: *'STeP let me present my product in the innovation and start-up fairs in Bangkok, Thailand. I got the award from the Thai Business Incubators and Science Park Association (Thai-BISPA). As a result, I was the representative of Thailand to present my product in the competitions in China and South Korea. I received the awards from Shanghai and received the grand prize from the Seoul International Invention Fair. Lastly, I presented my product in the Tech Innovation Fair in Singapore, making others know [about] my product.'*
3. The firm's product also received verification from the CMU laboratory, so customers can trust the quality. Moreover, the firm can grade the product and can estimate the selling price from the testing results.
4. The firm can sell the product in Thailand and plans to sell it internationally.

5.3.13 Section Summary

This section has detailed the findings from 12 case studies of more and less successful projects that CMU researchers undertook with spin-off firms from STeP programmes. Each case study begins with the project background. The roles of the university and relationships between the firm, CMU researcher and other actors in each case study are then illustrated from the pre-development phase through to the commercialisation phase. There were differences in the outcome of each case study, the firms and researchers; hence, the participants were asked to rate their project outcome. Finally, this section demonstrates the factors affecting the roles of the university within a peripheral region developing-economy context to commercialise the research results based on the firm and researcher ratings in each case study.

5.4 Conclusions

This chapter has outlined and summarised the data obtained in phases 1 and 2. The next chapter utilises this data, presenting the analysis, discussion and, by comparing these results with the existing literature in phase 3 of the research, identifying the contributions made by the thesis in answering research questions 2, 3 and 4.

Chapter 6: Analysis, Discussion and Identification of Contributions

6.1 Introduction

This chapter analyses the findings from both phases 1 and 2, and compares these with phase 3, in order to answer RQ2, RQ3 (both RQ3a and RQ3b) and RQ4 and identify contributions from the thesis. More specifically, this chapter consists of three main sections. The first section presents the roles of CMU and the relationships in the specific NT-RIS, the 'unique characteristics' of the roles of the university, and highlights the 'specific roles' of CMU in its relationships between the RIS, and science park actors in Northern Thailand, in order to answer RQ2. The second section illustrates the roles of the university and relationships within the RIS–university–science park nexus in the innovation projects between researchers and firms, answering RQ3a, as well as identifying success-driving factors (for on-park firms) to answer RQ3b. The third section answers RQ4.

6.2 The specific roles of the university and relationships between the RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)

To examine and analyse the empirical evidence from both phases 1 and 2 to answer RQ2, which is *'What are the specific roles of the university and relationships between the RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?'*, the following conceptual framework guides the analysis (see Figure 6.1).

Relationships between actors

Roles of University	RIS actors + University	RIS actors + University + SP	University + SP
	Knowledge co-creation (Basic Research)	Conduit (Product Development)	Inter-organisational relations (Applied Research)
Resource Sharing	(Cell 1) Provision of information	(Cell 2) Providing the channels of communication	(Cell 3) Provision of infrastructure
Brokerage Role	(Cell 4) Building regional networking	(Cell 5) Research collaboration (R&D activities between actors)	(Cell 6) Knowledge intermediaries
Exploitation and Commercialisation	(Cell 7) Economic development and wealth creation	(Cell 8) - Development of Commercialisation (e.g. licensing activities, patents) - Promoting technological change	(Cell 9) - Start-ups creation (incubator) - Promoting the commercialization of research results

FIGURE 6.1 A TWO-DIMENSIONAL MATRIX PRESENTING THE ROLES OF THE UNIVERSITY AND RELATIONSHIPS IN THE RIS–UNIVERSITY–SCIENCE PARK NEXUS.

To answer RQ2 and illustrate all roles played by CMU, the roles of the university and its relationships from the findings of phase 1 and in each case study of phase 2 were matched with the matrix (with each cell) to identify the differences and similarities (the consistency) between the data of both phases (see Table 6.1 which shows the degree of consistency between phases 1 and 2 as well as demonstrates the roles of CMU that support or differ from the existing literature). Additionally, Table 6.1 demonstrates the 'unique characteristics' of the roles of CMU when comparing them with the empirical evidence from the existing literature.

To answer RQ2, the number of roles played by CMU (frequency) in each cell of the matrix were counted and calculated as a percentage, which can be defined as the 'strength' of roles played by CMU (classified into strong role, moderate role and limited role). Then, the strength of roles played by CMU that support the existing literature are compared with the strength of roles observed in the existing literature in each cell of the matrix (see Table 6.2, which shows the theoretical synthesis of the university's roles from the literature to compare with the strength of the same roles played by CMU identified in phases 1 and 2). The results finally revealed CMU's 'specific roles' (or cells in the matrix) that have the levels of roles that are stronger than others (other cells), answering RQ2. Also, the results provide an overview of the specific RIS in Northern Thailand.

TABLE 6.1: THE DEGREE OF CONSISTENCY BETWEEN PHASES 1 AND 2 AS WELL AS SHOWING THE ROLES OF CMU THAT SUPPORT/DIFFER FROM THE LITERATURE

<table>
<tr><th>Cell 1
Provision of Information
(RIS actors + University)</th><th>Cell 2
Providing the Channels of Communication
(RIS actors + University + Science park)</th><th>Cell 3
Provision of Infrastructure
(University + Science park)</th></tr>
<tr><td>Phase 1:
Total participants = 11 persons
1) Information exchange or Information transfer by running SP or programme
(frequency = 4) (supports existing literature) (36.36%)

2) Information exchange through academic, business, and personal network
(frequency = 4) (supports existing literature) (36.36%)

3) Providing information through database
(frequency = 9) (differs from existing literature) (81.81%)</td><td>Phase 1:
Total participants = 8 persons
1) Casual social exchanges
(frequency = 4) (supports existing literature) (50%)

Total participants = 15 persons
2) Seminars
(frequency = 6) (differs from existing literature) (40%)

3) General business trainings and IP training
(frequency = 6) (differs from existing literature) (40%)</td><td>Phase 1:
Total participants = 8 persons
1) Building/ Space/Land
(frequency = 2) (supports existing literature) (25%)

2) Tools/ R&D infrastructure/ Laboratory equipment
(frequency = 2) (supports existing literature) (25%)

3) CMU café
(frequency = 6) (differs from existing literature) (75%)</td></tr>
<tr><td>The final percentage = 51.51%</td><td>The final percentage = 43.33%</td><td>The final percentage = 41.67%</td></tr>
<tr><td>Phase 2:
Total = 12 cases
1) Information exchange or Information transfer by running SP or programme
(frequency = 6) (supports existing literature) (50%)

2) Information exchange through academic, business, and personal network
(frequency = 7) (supports existing literature) (58.33%)</td><td>Phase 2:
Total = 12 cases
1) Casual social exchanges (frequency = 2)
(supports existing literature) (16.67%)

2) Meetings (frequency = 2)
(differs with existing literature) (16.67%)

3) Seminars (frequency = 2)
(differs from existing literature) (16.67%)

4) General business trainings and IP training
(frequency = 6)
(differs from existing literature) (50%)</td><td>Phase 2:
Total = 12 cases
1) Building/ Space (frequency = 1)
(supports existing literature) (8.33%)

2) Tools/ R&D infrastructure/ Laboratory equipment
(frequency = 9) (supports existing literature) (75%)

3) Factory/ Plant (frequency = 2)
(differs from existing literature) (16.67%)

4) Computer and Intranet (frequency = 2)
(differs from existing literature) (16.67%)

5) Library (frequency = 1)
(differs from existing literature) (8.33%)</td></tr>
<tr><td>The final percentage = 54.16%</td><td>The final percentage = 25%</td><td>The final percentage = 25%</td></tr>
<tr><td>Conclusion = Moderate consistency</td><td>Conclusion = Limited consistency</td><td>Conclusion = Limited consistency</td></tr>
</table>

Cell 4 **Building Regional Networking** **(RIS actors + University)**	**Cell 5** **Research Collaboration** **(RIS actors + University + Science park)**	**Cell 6** **Knowledge Intermediaries** **(University + Science park)**
Phase 1: **Total participants = 11 persons** **1) Provision of higher education and Training** (General business trainings and IP training) **(frequency = 5)** (**supports existing literature) (45.45%)** **2) Internship programs** **(frequency = 3)** (**supports existing literature) (27.27%)** **3) Mobility** **(frequency = 9)** (**supports existing literature) (81.81%)** **4) Generation of new technology and Supporting the spin-off of academic research (collaborating with the STeP)** **(frequency = 11)** (**supports existing literature) (100%)** **Total participants = 8 persons** **5) Formal programme** **5.1) Participating in programmes of other organisations/Academic Service (AS) programme** **(frequency = 4)** (**supports existing literature) (50%)** 5.2) Collaborating in the STeP programme (frequency = 2) **(differs from existing literature) (25%)** Total participants = 11 persons 6) Connection with others organisations (frequency = 8) **(differs from existing literature)** (72.72%) 7) Conference (frequency = 5) **(differs from existing literature)** (45.45%) 8) Excellent centre (frequency = 3) **(differs from existing literature)** (27.27%)	**Phase 1:** **Total participants = 8 persons** **1) R&D collaboration** **(frequency = 2)** (**supports existing literature) (25%)** **Total participants = 15 persons** **2) Joint research projects** **(frequency = 15)** (**supports existing literature) (100%)** **3) Providing a program of specialist seminars** **(frequency = 7)** (**supports existing literature) (46.67%)**	**Phase 1:** **Total participants = 8 persons** **1) Social contact networks** **(frequency = 8)** (**supports existing literature) (100%)** **2) Human resources** **(frequency = 8)** (**supports existing literature) (100%)** **3) Consulting** **(frequency = 8)** (**supports existing literature) (100%)** Total participants = 4 persons 4) Searching for additional knowledge, doing R&D activities, and transferring knowledge to firms (frequency = 2) **(differs from existing literature)** (50%) 6) Doing R&D activities and Transferring knowledge to firms (frequency = 2) **(differs from existing literature)** (50%)
The final percentage = 52.77%	**The final percentage = 57.22%**	**The final percentage = 80%**

Phase 2: **Total = 12 cases** **1) Provision of training** (General business trainings and IP training) **(frequency = 6) (supports existing literature) (50%)** **2) Generation of new technology and Supporting the spin-off of academic research (collaborating with the STeP) (frequency = 12) (supports existing literature) (100%)** **3) Formal programme** **3.1) Participating in programmes of other organisations/Academic Service (AS) programme** **(before attending the STeP programme) (frequency = 6) (supports existing literature) (50%)** 3.2) Collaborating in the STeP programme (development activities phase) **(frequency = 6)** **(differs from existing literature) (50%)**	**Phase 2:** **Total = 12 cases** **1) R&D collaboration** **(frequency = 6) (supports existing literature) (50%)** **3) Joint research projects** **(frequency = 12) (supports existing literature) (100%)** **4) Providing a program of specialist seminars** **(frequency = 4) (supports existing literature) (33.33%)**	**Phase 2:** **Total = 12 cases** **1) Social contact networks** **(frequency = 12) (supports existing literature) (100%)** **2) Human resources** **(frequency = 12) (supports existing literature) (100%)** **3) Consulting** **(frequency = 12) (supports existing literature) (100%)** 4) searching for additional knowledge, doing R&D activities, and transferring knowledge to firms (frequently = 9) **(differs from existing literature)** (75%) 5) Doing R&D activities and Transferring knowledge to firms (frequently = 3) **(differs from existing literature)** (25%)
The final percentage = 62.50%	**The final percentage = 61.11%**	**The final percentage = 80%**
Conclusion = Moderate consistency	**Conclusion = Moderate consistency**	**Conclusion = Strong consistency**

Cell 7 Economic Development and Wealth Creation (RIS actors + University)	Cell 8 Development of Commercialisation (e.g. Licensing Activities, Patents), Promoting Technological Change (RIS actors + University + Science park)	Cell 9 Start-ups Creation (Incubator), Promoting the Commercialisation of Research Results (University + Science park)
Phase 1: **Total participants = 11 persons** **1) Develop Informal and formal relationships with key actors (frequency = 6)** (**supports existing literature) (54.54%)** **2) *"Incubated ideas, educated entrepreneurs and fostered breakthrough technologies"* (Yoon et al., 2015) (collaborating with the STeP)** **(frequency = 11)** (**supports existing literature) (100%)** Total participants = 7 persons 3) Developing strategy aimed to produce research results that meet with the needs of industry making them to be commercialised **(collaborating with the STeP)** (frequency = 7) **(differs from existing literature)** (100%) 4) Having strategy to all faculties of CMU to provide academic services for general people or firms in Northern Thailand (frequency = 7) **(differs from existing literature)** (100%) 5) Having strategy to increase job opportunities for the local people and to promote start-up creation (frequency = 6) **(differs from existing literature)** (85.71%) 6) Having the policy to enhance the development of research in the sectors of food and health, energy and environment, and the creative and crafts, that are the main industries of Northern Thailand, to service firms (frequency = 7) **(differs from existing literature)** (100%)	**Phase 1:** **Total participants = 15 persons** **1) Intellectual property management** **(frequency = 10)** (**supports existing literature) (66.67%)** **2) Providing a resource for technical research and project- based support (to keep companies in the forefront of technological advances)** **(frequency = 15) (supports existing literature) (100%)** **Linking with science parks and other universities** **(frequency = 2/4) (50%)** 3) IP training (frequency = 6) **(differs from existing literature)** (40%)	**Phase 1:** **Total participants = 8 persons** **1) *"The enterprise starts its business operation directly from the university and relies on the business services of INNOTECH during their operation"* (Pálmai, 2004)** **(frequency = 1)** (**supports existing literature) (12.5%)** **2) *"Support for entrepreneurship policies and spin-offs helped promote Science Park and faculty members' participation in Science Park"* (Pálmai, 2004)** **(frequency = 8)** (**supports existing literature) (100%)** 3) Firms will spin-off from the STeP programme (frequency = 4) **(differs from existing literature)** (50%) 4) Some firms/University-Science park executives rated the programme of STeP and CMU can help them 100% in terms of exploitation and commercialisation (frequency = 6) **(differs from existing literature)** (75%)
The final percentage = 90.04%	**The final percentage = 68.89%**	**The final percentage = 59.38%**

Phase 2: **Total = 12 cases** **1) *"Incubated ideas, educated entrepreneurs and fostered breakthrough technologies"* (Yoon et al., 2015) (collaborating with the STeP)** **(frequency = 12)** (**supports existing literature) (100%)** 2) Developing strategy aimed to produce research results that meet with the needs of industry making them to be commercialised **(collaborating with the STeP)** (frequency = 12) **(differs from existing literature)** (100%)	**Phase 2:** **Total = 12 cases** **1) Providing a resource for technical research and project- based support (to keep companies in the forefront of technological advances)** **(frequency = 12)** (**supports existing literature)** **(100%)** **Linking with science parks and other universities** **(frequency = 6/12) (50%)** 2) IP training (frequency = 6) **(differs from existing literature)** (50%)	**Phase 2:** **Total = 12 cases** **1) *"The enterprise starts its business operation directly from the university and relies on the business services of INNOTECH during their operation"* (Pálmai, 2004)** **(frequency = 1)** (**supports existing literature) (8.33%)** **2) *"Support for entrepreneurship policies and spin-offs helped promote Science Park and faculty members' participation in Science Park"* (Pálmai, 2004)** **(frequency = 12)** (**supports existing literature) (100%)** 3) Firms spin-off from the STeP programme (frequency = 11) **(differs from existing literature)** (91.67%) 4) Some researchers/firms rated the outcome to be 100% (frequency = 7) **(differs from existing literature)** (58.33%)
The final percentage = 100%	**The final percentage = 75%**	**The final percentage = 64.58%**
Conclusion = Moderate consistency	**Conclusion = Moderate consistency**	**Conclusion = Moderate consistency**

From Table 6.1, limited consistency, which suggests differences between the broad stakeholder groups interviewed in phase 1 and those involved in the specific innovation projects analysed in stage 2, was only present in cells 2 and 3. The fact that the other cells showed stronger levels of consistency suggests that the two phases of research were broadly supportive of each other in terms of the evidence presented for RQ2. In cell 2, the limited consistency was caused by business training (identified strongly in phase 2), which comprised additional activities and roles carried out by CMU other than those that would be expected from the literature. This suggests that CMU provides channels of communication for actors that are at a similar level/stage of development. However, these activities are offered at a basic level because of the nature of the firms within the RIS. In cell 3, the limited consistency was caused by CMU's additional role of providing café (phase 1), computers and the library (phase 2), which was found to occur differently from the literature. This suggests that CMU's infrastructure is being used for basic capacity building, which also supports the evidence from cell 2. The fact that the differences were most apparent in the resource-sharing aspects of the process, and in areas where the university would have the most direct roles in providing resources, identifies this as the area where most discordance occurs, with phase 2 tending to identify additional, but more basic, resourcing activities, than phase one interviewees, suggesting a largely hidden (from the broader RIS) element of capacity building happening within this newly developed system.

TABLE 6.2: A THEORETICAL SYNTHESIS OF THE UNIVERSITY'S ROLES FROM THE LITERATURE COMPARED WITH THE SAME ROLES PLAYED BY CMU AND THE RESULTS FOR ANSWERING RQ2

Cells	Evidenced from the existing literature	Roles of universities (Universities/Countries)	Levels of university roles observed in the existing literature	levels of the observed roles in literature playing by CMU from phase 1	levels of the observed roles in literature playing by CMU from phase 2	Results from the comparison between the levels of university roles
Cell 1 Providing Information (RIS actors + University)	Boucke, Cantner, & Hanusch (1994)	Running a regional science centre aimed to coordinate cooperation and information transfer between the polytechnic and local firms (Ulm Polytechnic, Germany)	**Limited role**	**Limited role**	**Moderate role**	**limited role**
	Looy, Debackere, & Andries (2003)	Setting up a TTO where information flows were supported by staff of the TTO via information exchange through the industrial collaborative programme. (Katholieke Universiteit Leuven or KU Leuven R&D, Belgium)				
	Zou & Zhao (2013)	Having intense information exchange through academic, business, and personal networks (THU, China)		**Limited role**	**Moderate role**	
Cell 2 Providing Communication Channels (RIS actors + University + Science park)	Looy, Debackere, & Andries (2003)	Creating Leuven.Inc by KU Leuven R&D (TTO) and IMEC (the Inter-university Center for Micro-Electronics) for stimulating the exchange of ideas and the creation of networks. (Katholieke Universiteit Leuven or KU Leuven R&D, Belgium)	**Moderate role**	**None**	**None**	**limited role**
	Watkins-Mathys & Foster (2006)	Having casual social exchanges between researchers, entrepreneurs and officials within and outside the Chinese STIPs, as well as interactions in the community around the parks. (Chinese Universities, China)		**Moderate role**	**Limited role**	
	Zou & Zhao (2013)	The enterprises in TusPark that operated with THU can cooperate and communicate with Tsinghua alumni network. (THU, China)		**None**	**None**	
Cell 3 Providing Infrastructure (University + Science park)	Bruton (1998)	Providing space (Moscow Federal Institute of Electronic Technology (MIET), Russia)	**Moderate role**	**Limited role**	**Limited role**	**limited role**
	Westhead & Batstone (1998)	Providing access to facilities of HEI/centre of research. (UK universities, UK)		**Limited role**	**Moderate role**	
	Kihlgren (2003)	Providing the building (Russian universities, Russia)		**Limited role**	**Limited role**	
	Bigliardi, Dormio, Nosella, & Petroni (2006)	Providing access to the available tools (University of Padua, Italy)		**Limited role**	**Moderate role**	
	Hommen, Doloreux, & Larsson (2006)	Providing R&D infrastructure (Linköping University, Sweden)		**Limited role**	**Moderate role**	
	Sofouli & Vonortas (2007)	Providing access to the laboratories (University of Ioannina, Greece)		**Limited role**	**Moderate role**	

Cell 4 **Building Regional Networks** **(RIS actors + University)**	Storey & Strange (1998)	Providing a formal programme for distribution of knowledge from the university's research directly to firms (University of Aalborg, Denmark)	**Strong role**	**Moderate role**	**Moderate role**	**moderate role which is stronger than previous roles but still limited**
	Hommen, Doloreux, & Larsson (2006)	Provision of higher education and training, supporting the spin-off of academic research into a network of industrial firms and other organisations (Linköping University, Sweden)		**Provision of higher education and training: Moderate role supporting the spin-off of academic research: Strong role**	**Provision of higher education and training: Moderate role supporting the spin-off of academic research: Strong role**	
	Yoon, Yun, Lee, & Phillips (2015)	Making a transition toward being an entrepreneurial university by forming a consortium with other would-be entrepreneurial universities abroad and collaborating with foreign universities and attracting international students to the region. (Korea Advanced Institute of Science and Technology (KAIST), South Korea)		**None**	**None**	
	Lew, Khan, & Cozzio (2018)	Developing internship programmes (University of Trentino, Northeast Italy)		**Internship programmes and internationally connected via research: Limited role** **Regional mobility: Strong role**	**None** **(These two roles were observed in phase 1)**	
		Having internationally connected via research, mobility, and exchange programmes (University of Trentino, Northeast Italy)				
Cell 5 **Research Collaboration** **(RIS actors + University + Science park)**	Jonsson (2002)	Having collaborations between on-park firms, individual researchers or teams of researchers at universities, and hospital clinics (Universities in Lund, Sweden)	**Strong role**	**Limited role**	**Moderate role**	**moderate role**
	Bigliardi, Dormio, Nosella, & Petroni (2006)	Providing a programme of specialist seminars and a database that specifies the competences to companies in the innovation and technology transfer programme of the science park (University of Padua, Italy)		**Specialist seminars: Moderate role** **database: None**	**Specialist seminars: Limited role** **database: None**	
	Watkins-Mathys & Foster (2006)	Having commercial contracts for R&D product development (between university incubators and hi-tech STIPs firms) and offering financial loans to start-up companies to work on technology product development (Chinese Universities, China)		**None**	**None**	
	Sofouli & Vonortas (2007)	Having links with industry and research centres in joint research projects (Aristotelian University of Thessaloniki, Greece)		**Strong role**	**Strong role**	
	Malairaja & Zawdie (2008)	Having joint collaborative research with a science park and off-park firms (Malaysian University, Malaysia)				

Cell 6 **Knowledge Intermediaries** **(University + Science park)**	Jonsson (2002)	Having social contact networks in which the knowledge is channelled with on-park firms (Lund University, Sweden)	**Moderate role**	**Strong role**	**Strong role**	**moderate role which is stronger than others roles**
	Lai & Shyu (2005)	Providing a science park with high-quality human resources and on-job training (Shanghai Jiao Tong University and Fudan University, China)		**High-quality human resources: Strong role** **On-job training : None**	**High-quality human resources: Strong role** **On-job training : None**	
	Bigliardi, Dormio, Nosella, & Petroni (2006)	Consulting and providing access to online database (University of Padua, Italy)		**Consulting:** **Strong role** **database: None**	**Consulting:** **Strong role** **database: None**	
		Collaborating with the science park to provide quality and certification programme offering integrated services such as consulting, testing, certifying the quality required for commercialising products, etc. (University of Padua, Italy)		**Strong role**	**Strong role**	
Cell 7 **Economic Development and Wealth Creation** **(RIS actors + University)**	Gunasekara (2006)	Development of a technology precinct and Innovation Campus, as well as development of informal and formal relationships with key actors (Provincial city University, Australia)	**Limited role**	**Development of a technology precinct/Innovation Campus: None** **Development of informal and formal relationships with key actors: Moderate role**	**Development of a technology precinct/Innovation Campus: None** **Development of informal and formal relationships with key actors: None** **(This role was observed in phase 1)**	**limited role**
	Yoon et al. (2015)	Having incubated ideas, educated entrepreneurs and fostered breakthrough technologies (Stanford University, USA)		**Strong role**	**Strong role**	
		Establishment of technology holding companies (Electronics and Telecommunications Research Institute (ETRI) and Korea Advanced Institute of Science and Technology (KAIST), South Korea)		**None**	**None**	

<table>
<tr><td rowspan="3">Cell 8
Commercialising
(e.g., Licensing Activities, Patents),
Promoting Technological Change
(RIS actors + University + Science park)</td><td>Hommen, Doloreux, & Larsson (2006)</td><td>Development of Commercialisation (e.g., Licensing Activities, Patents)
Having a university holding company located in science park, which commercialises research and ideas serving as ‘a bridge between the academic and commercial worlds’ and providing faculty and students of the university who are intent on establishing new businesses with referrals to a number of key services related to the commercialisation of research results, in such areas as IP management, access to seed capital, etc.
(Linköping University, Sweden)</td><td rowspan="3">Limited role</td><td rowspan="2">Moderate role</td><td rowspan="2">None</td><td rowspan="3">limited role</td></tr>
<tr><td>Xie et al. (2018)</td><td>Intensive interactions with government, enterprises, universities, and agencies have led Donghu High-Tech Zone to become an industrial ecosystem. Parties such as universities and research institutes, venture capital institutions, and business incubators provide a variety of input factors for technology start-ups through the transfer of IP rights or cooperative development. (Universities in Donghu High-Tech Zone, China)</td></tr>
<tr><td>Guy (1996)</td><td>Promoting Technological Change
Linking with science parks and other universities, aimed to help and keep companies in the forefront of technological advances by providing a resource for technical research and project-based support
(Aston University, UK)</td><td>Moderate role</td><td>Moderate role</td></tr>
<tr><td rowspan="6">Cell 9
Creating Start-ups (Incubator),
Promoting the Commercialisation of Research Results
(University + Science park)</td><td rowspan="2">Pálmai (2004)</td><td>University teachers move their enterprises to the site of the innovation park, establish their own real enterprises and convert the virtual companies into legal entities. (process)
(Budapest University of Technology and Electronics, Hungary)</td><td rowspan="6">Strong role</td><td>None</td><td>None</td><td rowspan="6">moderate role which stronger than others roles</td></tr>
<tr><td>Enterprise starts its business operation directly from the university and relies on the business services of the innovation park during their operation (process)
(Budapest University of Technology and Electronics, Hungary)</td><td>Limited role</td><td>Limited role</td></tr>
<tr><td>Shearmur & Doloreux (2000)</td><td>Creating an incubator programme for some science parks
(Canadian Universities, Canada)</td><td>None</td><td>None</td></tr>
<tr><td>Feldman (2007)</td><td>Supporting for entrepreneurship policies and spin-offs helped promote the science park and faculty members’ participation in the science park
(Swedish Universities, Sweden)</td><td>Strong role</td><td>Strong role</td></tr>
<tr><td>Zou & Zhao (2013)</td><td>One of the initial missions that the university-established science park was ‘Promoting the commercialisation of research results’
(THU, China)</td><td>None</td><td>None</td></tr>
</table>

Based on the conceptual framework (see Figure 6.1), the following sections provide evidence of roles/activities in each of the nine cells highlighting all the roles of the CMU and its relationships within the NT-RIS (as demonstrated in Table 6.1). It also uncovers CMU's 'specific' roles from the results of the comparison between the levels of university roles observed in the existing literature and those of the same roles played by CMU from both phases (as presented in Table 6.2). As can be seen, in cells 2, 3, 4, 5 and 9, CMU is playing less of a role than would be suggested by the literature, while the strength of its roles is consistent with the literature in cells 1, 6, 7 and 8. The detail related to this, as well as what this tells us about the system, is provided below.

6.2.1 Cell 1: Providing information

To share resources and strengthen the RIS, universities play a role in providing or exchanging information with RIS actors. According to Zou and Zhao (2013), universities exchange information through 'academic, business, and personal network[s]'. Some universities ran science parks or TTOs for transferring information from academics to firms in the region (Boucke et al., 1994; Looy et al., 2003). Similarly, CMU collaborated with STeP to allow researchers to transfer information to firms in the region through their personal links. This highlighted evidence from CMU's case supports evidence of Boucke et al. (1994), Looy et al. (2003), and Zou and Zhao (2013). Empirical evidence of this thesis illustrates the cycle of information flow between some regional firms and CMU researchers. This started with firms and researchers undertaking prior projects in public sector programmes before attending the STeP programme. They had 'strong' personal links and exchanged information after finishing the prior project, as noted by one participant: *'I knew [the] researcher before attending the STeP programme because we did [a] prior project in [the] academic service programme of CMU. Firstly, I gave information of my new product to [the] researcher aiming to do [the] new project. Then, he provided information of [the] STeP programme. Finally, I decided to participate [in] the programme for developing [a] new product'* (SOF1). Findings from phase 2 affirmed that researchers in six cases (cases 1, 2, 4, 5, 7 and 9) provided information to firms in the pre-development phase.

The cycle then moved to the commercialisation phase, demonstrating that some firms and CMU researchers still kept in contact after leaving the programme and exchanged information. According to SOF3, the *'Researcher provided information of technique[s] to produce the product. He provided information by using telephone call[s] and [the] LINE application. We also shared information after spin-off.'* Evidence from phase 2 also showed that spin-off firms and researchers from seven cases (cases 1, 2, 4, 5, 6, 7 and 8) exchanged information, highlighting the information flow between the university and firms in the RIS.

Interestingly, interview data from the university and science park executives illustrated that CMU provides information from researchers and about laboratory equipment through its database, highlighting the 'unique characteristics' of this role: *'CMU has provided information, such as the expertise of researchers and research interest, laboratory equipment etc., to everyone who can access to see details in the Science and Technology Infrastructure Databank (STDB)'* (UPE1).

Because phase 2 focuses on the roles of the university and relationships between firms, researchers and other actors within each project, no participants indicated that CMU provided information through the database.

To support this role, MOST provided CMU with a policy. According to PPA2, *'MOST gave [a] policy to CMU for allowing its researchers to add their details, including research details, resume and research interest[s], into the STDB. So, everyone can receive information of CMU through this updated database.'* This implies that the government created the database policy for CMU and other universities.

Compared with the same role observed in the literature, this role played by CMU can be defined, consistent with the broader literature, as a 'limited role', specifically because some firms and researchers did not keep in contact and exchange information after spin-off. However, there has also been an addition to the previous literature in terms of the activities identified, namely the provision of information by CMU through its database, which highlights another way in which relevant information can flow, albeit taking a relatively basic and codified form (as opposed to the often more valuable tacit knowledge that flows via other mechanisms). In sum, the findings illustrate a specific NT-RIS, where some CMU researchers and firms exchange information through their personal links and in which CMU also provides information through a database that all actors in the RIS can access.

6.2.2 Cell 2: Providing communication channels

Acting as the centre of the RIS, universities have the role of providing communication channels between actors for transferring knowledge. In the case of China, universities had casual social exchanges between researchers, entrepreneurs and officials within and outside science, technology and innovation parks (STIPs) (Watkins-Mathys & Foster, 2006). Similar to the evidence in China, some on-park firms, spin-off firms and CMU researchers had casual social exchanges through general business and technology training and seminars. As only two firms (cases 1 and 7) from phase 2 attended training and had social exchanges with other actors in the RIS, this illustrates that this role of CMU was limited.

The university also collaborated with other organisations to create and build networks and stimulate the exchange of ideas (Looy et al., 2003), CMU's links tended to be informal. Evidence from Zou and Zhao (2013) showed that enterprises in TusPark cooperated and communicated with the Tsinghua alumni network. The STeP's on-park firms, however, did not collaborate with the CMU alumni network, implying that more formal links do not yet exist.

The 'unique characteristics' of this role were observed. Firstly, evidence revealed that CMU provided channels of communication between actors in the RIS through general business training and seminars as well as IP training. This highlighted that CMU builds regional networks from these roles. Secondly, CMU researchers from two cases (cases 7 and 11) set up meetings as the channel of communication between the firm, researcher and RIS experts. As these characteristics did not appear in literature, they were considered as 'unique characteristics' of this CMU role.

Although CMU provided channels of communication between actors in the RIS, more social exchanges between on-park and spin-off firms were observed. However, the knowledge was transferred from the university to actors in the RIS, as indicated by

SOF3: *'I had a few social exchanges with on-park firms and experts in IP training of CMU, but I did not have any conversation with other spin-off firms…I think knowledge was transferred through training because CMU brought experts in IP management to give me the additional knowledge'*.

Compared with the same role observed in the literature, this role can be defined as a 'limited role' rather than the moderate role identified in the literature. This suggests that, because CMU has not created all the link types that are potentially possible, on-park firms do not cooperate with the CMU alumni network and have more limited social exchanges among researchers, on-park firms, spin-off firms and RIS actors. Instead, and as an addition to the literature, CMU set up seminars and business training, suggesting that the university aimed to offer communication channels at a more basic level than identified in the literature, for actors at the same level/stage of development. This is likely because of the nature of the firms within the system. In sum, the findings illustrate that in the specific NT-RIS, CMU acted as a centre, supporting the development of what is still a relatively new RIS. It provided channels of communication to link the science park and RIS actors together, but these links between the on-park firms, spin-off firms and other RIS actors from this role have been limited and can be seen to be very much developmental.

6.2.3 Cell 3: Providing infrastructure

As observed in the literature, some universities support science parks and on-park firms by providing infrastructure. Prior research shows that universities offer space (Bruton, 1998), buildings (Kihlgren, 2003) and R&D infrastructure (Hommen et al., 2006) to science parks. Likewise, CMU provided the space to STeP to enable it to establish its headquarters. However, as only one researcher (from case 6) used CMU space to undertake the project, this illustrates that this role is limited thus far.

Universities also allow on-park firms to access facilities of the HEI/centre of research (Westhead & Batstone, 1998), available tools (Bigliardi et al., 2006) and laboratories (Sofouli & Vonortas, 2007). In the case of CMU, some researchers and firms from phase 1 and from nine cases (cases 1, 2, 3, 5, 8, 9, 10, 11 and 12) of phase 2 used laboratory equipment. This emphasises that researchers used CMU infrastructure rather than forming joint activities between researchers and firms.

It is apparent that some researchers and on-park firms used the CMU café as a meeting place. Evidence from phase 2 showed that researchers from two cases (cases 1 and 4) used the CMU plant and factory. Some researchers and firms used CMU computers, the intranet and online library, as well as CMU's library. Because this evidence did not appear in the literature, it highlights the 'unique characteristics' of this role.

Comparing this role of CMU with the same role observed in the literature, it can be defined as a more 'limited role' than the moderate role identified in the literature because most on-park firms did not use CMU infrastructure. In sum, the findings illustrate that, in the specific NT-RIS, researchers used CMU infrastructure to perform R&D activities for on-park firms. This implies that most on-park firms did not participate in R&D activities and they did not use CMU R&D infrastructure. Instead, and in addition to the literature, their use of the café, computers and library suggests the use of more basic generic infrastructure, again implying that the university infrastructure is being used for more basic capacity building, which supports the evidence presented for cell 2.

6.2.4 Cell 4: Building regional networks

The literature on RISs concerned interactive learning among actors; universities, therefore, have the role of building regional networks with other actors. To do this role, universities *'provided higher education and training'* and *'supported the spin-off of academic research into a network of industrial firms and other organizations'* (Hommen et al., 2006). Similarly, CMU provided general business training and IP training to actors in the specific NT-RIS. Evidence from phase 2 showed that firms from six cases (cases 1, 3, 4, 10, 11 and 12) attended IP training and had connections with experts in the commercialisation phase. This supported that CMU kept contact and built regional networks with firms even after spin-off.

To perform this role, universities also provided a 'formal programme' to distribute knowledge to firms in the region (Storey & Tether, 1998). In the case of CMU, it allowed researchers participating in the AS programme, formal public sector programmes as well as the STeP programme to perform R&D activities with firms in the region. Findings from phase 2 showed that the researchers and firms from two cases (cases 1 and 8) participated in CMU's AS programme before attending the STeP programme, while the researchers and firms from four cases (cases 2, 4, 6 and 7) participated in other public sector programmes. This emphasises the links between CMU and RIS actors through 'formal programmes'.

According to Yoon et al. (2015), universities also formed a consortium with international universities and attracted international students to the region to build networks. CMU did not, however, operate in this manner. To link with other actors, universities 'developed internship programs' and 'had internationally connected through research, mobility, and exchange programs' (Lew et al., 2018). By contrast, some CMU researchers participated in the Talent Mobility programme to work with firms full-time. Additionally, CMU connected with actors from abroad through research. Evidence from the case of CMU, thus, supports some details of the evidence from Lew et al. (2018).

There were 'unique characteristics' of this role played by CMU that did not appear in the literature. Firstly, CMU set up an annual conference to link researchers with RIS actors in the region. As no participants in phase 2 attended the conference, this role appears to be limited. Secondly, CMU built regional networks with six universities in Northern Thailand through academic networks and by setting up excellence centres. According to UPE3, *'25 excellence centres were established by CMU for serving firms in the region. The centres provided laboratory services and had [a] connection with both public and private sectors.'* This emphasises the strong academic connections between universities in Northern Thailand.

Compared with the same roles observed in the literature (where cell 4 is defined as being a strong role for universities), the role played by CMU can be defined as being a 'moderate role', which is stronger than the previous roles but still more limited than in the literature. This is because CMU did not form consortiums to attract overseas students, or have networks with actors from abroad through student or staff mobility and exchange programmes. Instead, and adding to the existing literature, more basic connections (e.g., through conferences and excellence centres) were established. In sum, the findings illustrate that it is the regional links between CMU and RIS actors in Northern Thailand that are still being established, suggesting again a greater degree of new capacity building activity. Nevertheless, CMU should also build more networks not only in Thailand but also with other countries.

6.2.5 Cell 5: Research collaboration

To connect with actors in the RIS and produce new knowledge, universities cooperate with RIS actors and science parks in research collaboration. In this thesis, research collaboration is defined as not only undertaking R&D activities in joint projects but also includes participating in technology transfer programmes, having commercial contracts and offering financial loans.

Prior research indicates that universities have 'collaborations' between on-park firms, researchers and other RIS actors, as well as having 'joint research projects' with on-park firms (Jonsson, 2002; Malairaja & Zawdie, 2008; Sofouli & Vonortas, 2007). This accords with the case of CMU, in that it collaborated with STeP to allow researchers to perform R&D activities with firms and other RIS actors in joint research projects. According to SOF1,

> *'I attended the IRTC programme. I signed [a] contract with STeP and got additional funding from SPA/MOST. In my project, I received laboratory services from [a] researcher in the Faculty of Pharmacy, CMU. Moreover, [the] researcher did some parts of [the] R&D activities with experts from Maejo University. I also participated in some experiment[s] as well.'*

Evidence from phase 2 affirmed that some researchers collaborated with experts from other universities and the private sector to develop new products and processes (cases 1, 5 and 8), a mobile application (case 7), packaging (case 11), and for testing products (case 12). However, collaborating with other experts in the RIS usually depended on the nature of each project and the researcher's knowledge. According to Researcher E from case 7, *'Our project aimed to develop [a] mobile application that can control the system of [the] Modular Farm. To do this project, it needed to combine more than one research field. Therefore, I invited the expert in hydroponic farms from [the] private sector in Northern Thailand and the expert in growing of vegetables by using the LED [a light-emitting diode] as well as the expert in censors from Maejo University to participate in our research collaboration by myself.'*

To fulfil this role, universities provide seminars to firms in science park technology transfer programmes (Bigliardi et al., 2006). Similarly, CMU offered seminars to on-park firms in the STeP programme and to spin-off firms. Evidence from phase 2 supports that firms from four cases (cases 1, 2, 3 and 7) attended these seminars. Further, university incubators and STIP firms in China had *'commercial contracts for R&D product development'* and the incubators also *'offered financial loans to start-up companies for working on technology product development'* (Watkins-Mathys & Foster, 2006). Thus, this evidence from China did not appear in the case of CMU.

Comparing this role played by CMU with the same role observed in the literature (where universities have a relatively strong role), it can be defined as a 'moderate role'. Most characteristics of this role are similar to those from the literature. However, CMU did not have commercial contracts for product development and did not offer financial loans. In comparison with the existing literature, CMU does not undertake additional activities but, rather, undertakes similar activities to those found in the existing literature to a more moderate extent. The highlighted areas where CMU is deficient again suggests that the university's activities in these areas are at a relatively early stage which, given the evidence from previous cells, would also suggest an early-stage RIS in this region. In sum, the findings illustrate that in the specific RIS for Northern Thailand, CMU provides seminars to on-park and spin-off firms, CMU researchers collaborate with STeP and firms to undertake joint research projects and, depending on the nature of project and knowledge of the researcher, some projects also have other RIS actors participating.

6.2.6 Cell 6: Knowledge intermediaries

As universities have links with science parks, this highlights that universities can act as knowledge intermediaries. To perform this role, the university has 'social contact networks' with on-park firms (Jonsson, 2002). In this study also, the researchers had social contact networks with firms, STeP staff and other participants in their projects.

According to Lai and Shyu (2005), universities also perform this role by offering *high-quality human resources'* and *'on-job training'* to science parks. By allowing researchers to participate in the STeP programme, CMU also offered 'high-quality human resources' to the science park. Because CMU did not provide on-the-job training, however, the evidence from the CMU case only partially supports the literature in this area.

Acting as knowledge intermediaries, universities collaborate with science parks to provide programmes that service firms and allow firms to access their online databases (Bigliardi et al., 2006). Supporting the evidence from the literature, CMU collaborated with STeP in the IRTC programme to allow researchers to provide services to firms by performing R&D activities and providing advice. In terms of consulting, CMU researchers provided knowledge and advice in meetings and by using the LINE application, telephone calls and email. According to OPF4, *'[the] Researcher set up meetings to present the progress of [the] project. He also gave advice and provided knowledge of laboratory equipment, cosmetics, as well as methods to produce my new product. When I have questions about [the] research results, I contact the researcher by using LINE, telephone call and email'*. Additionally, the firm also benefited as *'There are a lot of benefits. Because [the] researcher has been an expert in chemistry and herbs, he gives me valuable advice related to cosmetics. Moreover, [the] researcher helped me test the extracts from different rice varieties to find which one had been the best and [was most] suitable to combine into [a] new product. As he got [the] research results, he used them to develop my new product and transferred the knowledge, as well as methods to produce the new product, to me'* (OPF4). In sum, this illustrates a one-way transfer of knowledge from CMU to the firm – rather than a true collaboration, which might suggest a lack of firm-level knowledge.

Evidence in this thesis illustrates two different knowledge intermediary processes, highlighting the 'unique characteristics' of this role in this context. First, the one-way, top-down, process started with CMU researchers searching for new knowledge, followed by the R&D activities and then transferring knowledge to the firms. Researchers from two projects in phase 1 and from nine cases (cases 1, 2, 4, 7, 8, 9, 10, 11 and 12) in phase 2 served firms through this process. In the second process, researchers only performed R&D activities and transferred knowledge to the firms. Researchers from two projects in phase 1 and from three cases (cases 3, 5 and 6) in phase 2 served firms using this process.

Comparing this role with the same role observed in the literature, this role performed by CMU can be considered as a 'moderate role'. This is stronger than other roles, and consistent with the strength of the role indicated in the broader literature. In addition, there are additional activities identified as compared to the literature in terms of the university searching for additional knowledge, undertaking R&D activities and transferring knowledge to firms, suggesting that CMU is taking a more active role than would normally be the case (as indicated in the literature), which itself may suggest a firm capacity issue consistent with the peripheral developing-economy status of Northern Thailand. In sum, the findings illustrate that CMU, in the NT-RIS, acts as a strong direct knowledge intermediary, with researchers using 'apparent processes' to transfer knowledge to on-park firms.

6.2.7 Cell 7: Economic development and wealth creation

As one component in the RIS, the university connects with RIS actors and has the role of developing the regional economy. To do this role, some universities establish technology holding companies, develop technology precincts and innovation campuses, as well as build informal and formal relationships with key actors (Gunasekara, 2006; Yoon et al., 2015). By contrast, CMU only developed informal and formal links with other actors. According to PPA2, *'CMU connected with public and private sector [actors] not only in Northern Thailand but also in Bangkok. To do this, CMU connected through both informal and formal links aiming to share resources for developing [the] economy* *and supporting the wealth creation of firms in the region.'* This provides evidence confirming some of the details found in the literature.

To enhance the local economy, Stanford University 'incubated ideas, educated entrepreneurs and fostered breakthrough technologies' (Yoon et al., 2015). Linking this to the findings of this thesis, CMU also adopted this process by collaborating with STeP, highlighting the initial step in following Stanford University's pathway.

The main CMU strategy for researchers was producing research results to meet the needs of industry. As a result, firms from two cases (cases 1 and 4) commercialised new products in Thailand and international countries. Additionally, firms from three cases (cases 7, 8, and 11) commercialised products in Thailand, the firm in case 6 used the machine developed in its production, and the firm in case 12 obtained laboratory results for use in commercialisation.

Findings from this thesis, however, also identify strategies and one policy to promote its economic development and wealth-creating role, which are considered to be 'unique characteristics' of this role carried out by CMU. These strategies included all faculties of CMU aiming to offer academic services for firms in the region, as well as increasing job opportunities and promoting start-up creations. Lastly, CMU has one policy to promote this role. According to UPE3, *'CMU had one policy to push the development of research in the fields of food and health, energy and environment, and the creative and crafts, which are main industries of Northern Thailand, aiming to support and service firms in the region.'* In sum, CMU has regionally focused strategies, using very specific expertise, through specific demand from specific firms.

Compared with the same role observed in the literature, this particular role can be defined as a 'limited role', which is consistent with the relative strength of this role for universities in the existing literature. The activities CMU is undertaking, which are in addition to those found in the literature, are based around developing strategies, again indicating the early stage of CMU's and the RIS's activities. Specific suggestions for future activity would therefore revolve around aspects identified in the literature that are currently missing, including that CMU should create a technology precinct and innovation campus, as well as establish a technology holding company for developing the Northern Thailand economy. The findings from this thesis illustrate a specific NT-RIS, with CMU connecting both formally and informally with the main actors in both Northern Thailand and Bangkok, the capital city, to develop the regional economy, as well as collaborating with the science park (STeP) and having strategies and policies to support this role of university.

6.2.8 Cell 8: commercialising and promoting technological change

As the centre of the RIS, universities have the role of commercialising research results and promoting technological change to actors in the system. Evidence from Guy (1996) shows that Aston University collaborated with a science park and other universities in order to help keep companies at the forefront of technological advances through provision of technical research and project-based resources. Similarly, CMU allowed researchers to participate in the STeP programme to undertake R&D activities. As a result, firms obtained research results or a new product that could be commercialised in the market. This highlights CMU promoting technological change to firms. The following quote illustrates the linear process to promote technological change:

> *'I conducted research to develop [a] new product of firm. After firm spin-off, STeP staff contacted [the] firm to present and launch [the] new product in the innovation fairs. So, this is the process that STeP and CMU [used to] promote the technological change'* (Researcher A, case 1).

In terms of commercialisation, Linköping University had its own holding company located in science park, offering services such as IP management, access to seed capital, and so on, to academics who were interested in setting up a business. (Hommen et al., 2006). Universities and research institutes, venture capital institutions and business incubators in Donghu High-Tech Zone also support this role through the transfer of IP rights for technology start-ups (Xie et al., 2018). By contrast, CMU provided IP services only to on-park firms and spin-off firms.

Evidence from this thesis provides additional details of how CMU is helping firms to manage IP, which highlights the 'unique characteristics of this role'. Firstly, CMU established a TLO to help researchers and firms manage their IP. Secondly, it offered IP services, including consulting and training, to firms. There were some firms from phase 1 and six cases (cases 1, 3, 4, 10, 11 and 12) from phase 2 that attended the IP training. However, none of them registered their research results as a patent, emphasising that this role is still limited.

To support IP management, CMU adopted a strategy for researchers to register their research results as the patent, petty patent, and copyright. Moreover, CMU had a policy to promote this role by allowing researchers to use a number of patents claiming their academic position.

Compared with the same role observed in the literature, this role can be defined, consistent with the broader literature, as a ‘limited role’, because CMU offered an IP service, but none of the firms are managing their IP. Unsurprisingly, therefore, an addition to the previous literature is CMU’s provision of IP training to firms, again indicating the firm capacity-building nature of many of the university–firm interactions. In sum, the findings illustrate a specific NT-RIS where CMU is promoting technological change by collaborating with STeP to allow researchers to undertake R&D activities with firms. As a result, firms graduating from the STeP programme can commercialise their research results, with CMU also providing IP services to all firms, including training.

6.2.9 Cell 9: Creating start-ups and promoting the commercialisation of research results

As universities collaborate with science parks, they can play a role in encouraging on-park firms up to spin-off as well as supporting the commercialisation of research results. Pálmai (2004) identified two processes relevant to start-up creation that relate to this role of the university, in the case of Budapest University of Technology and Electronics. The first process, described by Pálmai (2004) as university teachers moving their proto-enterprises to innovation park and converting them into real, legal, entities, did not appear in the CMU case. This illustrates that most university staff were not setting up their own firms, but rather were helping firms that participated in the science park programme to take advantage of their help. Additionally, the second process of Pálmai (2004), when an enterprise starts up business operation directly from the university and relies in its operations on business services provided by the park was only seen on one firm in phase 1 and one case (case 12) in phase 2 of the CMU.

Promoting the commercialisation of research results was one of the initial missions of THU when setting up the science park (Zou & Zhao, 2013), while CMU implemented the government policy by setting up STeP, but did not itself have an initial mission to establish a science park. In order to support start-up creation, Canadian universities created an incubator programme for some science parks (Shearmur & Doloreux, 2000). Conversely, SPA designed the STeP incubation programme, emphasising that CMU is reactive rather than proactive. According to Feldman (2007), universities in Sweden support entrepreneurship policies and spin-offs, helping to promote the science park and attract faculty members to participate. CMU also collaborated with STeP to help firms develop new products and spin off from the programme. As some spin-off firms commercialised new products, CMU can therefore promote STeP from these success stories. This supports Feldman's (2007) evidence.

To measure the results from this role, participants in phase 1 were asked to rate the STeP programme in terms of helping them to exploit and commercialise the research results. The results showed that most participants gave a rating of 100%: *'I rated 100% because the programme of STeP that collaborated with CMU can help firms to develop new products and they can commercialise new products in the real market'* (UPE1). Moreover, all on-park firms believed that they would spin-off from the programme successfully. According to OPF1, *'I believed that [the] CMU researcher can help me [in] developing my new product. Then, I will spin-off and can sell it in Thailand.'*

To demonstrate the results from this role of the university, firms and researchers in each project of phase 2 were asked to rate the outcome of their project. Firms and researchers from seven cases (cases 1, 3, 4, 6, 8, 11 and 12) rated the outcome of their projects to be 100%, highlighting that CMU or the researchers performed this role successfully. Whilst the notion of 100% satisfaction seems surprising, this could reflect the specific Thai culture that has a high level of 'deference to authority and strong sense of social cohesiveness' (Hallinger & Kantamara, 2001; Kainzbauer & Hunt, 2016) and the cultural norm of "krengjai" which means displaying 'deference toward others' (Pornpitakpan, 2000) or 'honour and respect to someone of a higher social position'

(Hilderbrand, 2020) as the research is a government sponsored PhD student and the participant might deference to the government. However, firms and researchers from five cases (cases 2, 7, 5, 9 and 10) rated the outcome of their project to be less than 100% due to the duration of the STeP programme being too short (cases 2 and 7), the new product not being finished and the researcher needed to finish it in the next project (case 5), that the firm was looking for an OEM and the new product has not been launched (case 9), or the firm needed to develop packaging for the new product (case 10). All of these can be seen as related to firm capacity as well as university capacity issues. However, since other projects were successful, the stated success levels are likely more related to the capacity of the specific firms. Overall, therefore it was identified that splitting the results into two categories, 100% successful and less than 100% successful was the most viable approach.

Comparing this role performed by CMU with the same role observed in the literature, CMU's role can be defined as a 'moderate role' which is stronger than other roles of the university but is not as strong as the 'strong' role that universities normally play in this aspect, as indicated by the literature. The fact that the differences with the existing literature revolve around the additional exploitation and commercialisation support that the university could give to firms but that they were 'spun off' the science park following the conclusion of the programme, supports this more moderate role of CMU, again indicating the early stage of the development of this RIS–university–science park nexus. In sum, the findings illustrate a specific NT-RIS in which CMU collaborated with STeP to help firms undertake R&D activities and spin off from the programme. However, some spin-off firms have not commercialised their new products, suggesting that CMU and STeP should extend the duration of the STeP programme for some projects, support firms after spin-off, and provide greater encouragement to academics interested in establishing businesses to participate in STeP programmes.

6.2.10 Summary and identification of contribution

The findings from this section answer RQ2 by presenting the 'specific roles' of CMU in the NT-RIS. Comparing each role performed by CMU in the conceptual framework with those from the existing literature, the result shows that CMU has four specific roles in building regional networks, research collaboration, knowledge intermediaries, and creating start-ups and promoting the commercialisation of research results. However, CMU's role as a knowledge intermediary is considered to be the most specific role. This is because most characteristics of this role are similar to those from the existing literature, and all CMU researchers who participated in the STeP programme have an 'apparent process' to transfer knowledge to firms.

In comparison with the existing literature, evidence from the CMU case illustrates additional details which are different from those in the existing literature. In particular, some roles/activities played by CMU are distinctive and are more varied than those observed in the literature, making the contribution of identifying new roles of the university and its relationships with actors in a peripheral RIS in a developing-economy context. Hence, this highlights the 'unique characteristics' of the role of CMU in a specific NT-RIS, including:

1) Regarding the role of the university to provide information, CMU provided information to RIS actors via a database.
2) Regarding the role of the university to provide communication channels, CMU offered general business training, seminars and IP training to all actors in the NT-RIS. Moreover, researchers who participated in the STeP programme set up meetings as the channel of communication between firms, researchers and other participants in their projects.
3) Regarding the role of the university to provide infrastructure, researchers and firms who participated in the STeP programme could use the CMU café, plant and factory, library, intranet and online library as well as computers.
4) Regarding the role of the university to build regional networks, CMU set up an annual conference and excellence centres, as well as connected with other universities in Northern Thailand.

5) Regarding the role of the university to perform as a knowledge intermediary, some CMU researchers who participated in the STeP programme transferred knowledge to firms by searching for new knowledge, performing R&D activities and finally transferring knowledge to firms. However, another group of researchers performed this role by undertaking R&D activities and transferring knowledge to firms.
6) Regarding the role of the university in relation to economic development and wealth creation, CMU presents unique characteristics of this role by having some strategies and only one policy to promote this role.
7) CMU set up a TLO to help researchers and firms to manage their IP. It also offered IP services (consulting and training) to firms. This highlights the unique characteristics of the role of CMU in commercialising research efforts and promoting technological change.

Summing up, CMU is relatively new to the role of the entrepreneurial university. The NT-RIS is largely still nascent. As firms have capacity issues, which the university is simultaneously having to address, CMU served firms with capacity building activities.

The outcomes of projects between firms and researchers vary both in terms of being successful or less successful. In the case of successful outcomes, firms benefited from the research collaboration between the firms and researchers, regional networking between CMU researchers and other RIS actors to serve the firms, as well as the role of the researcher as a knowledge intermediary. This emphasises that the successful outcome of projects not only came from the university's capacity but also from the capacity building of firms. To support capacity building, CMU and STeP should extend the duration of the STeP programme for some projects and support firms after spin-off.

This section therefore contributes to the literature on RISs and science parks by presenting the roles of CMU and the relationships that exist in the RIS–university–science park nexus in Northern Thailand. As this thesis identified the differences and similarities between the roles of CMU with those from the literature, it showed the 'unique characteristics' of the roles of CMU and provided an overview of a RIS in the specific region of Thailand. The next section explains in-depth the interactive innovation processes and relationships among actors in a specific NT-RIS.

6.3 The roles of the university in its relationships with RIS, university and science park actors in innovation projects conducted by the university with on-park firms and its contribution to the innovation activities of on-park firms in the context of a peripheral developing economy

RISs are related to institutional settings, technological change and the interaction between actors in a specific region (Cooke, Gomez Uranga, et al., 2003). As a system, the RIS is concerned with the interactive innovation processes between actors, including firms, universities, public and private organisations, research institutions, and so on.

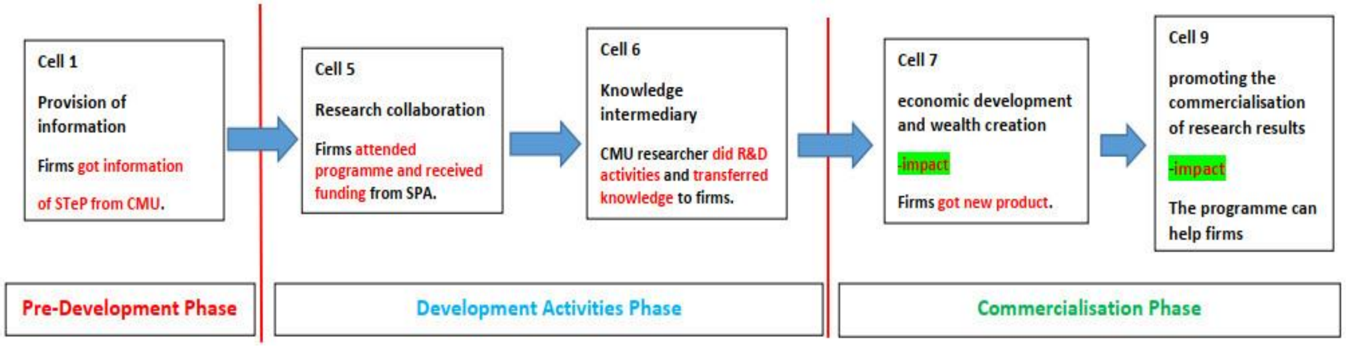
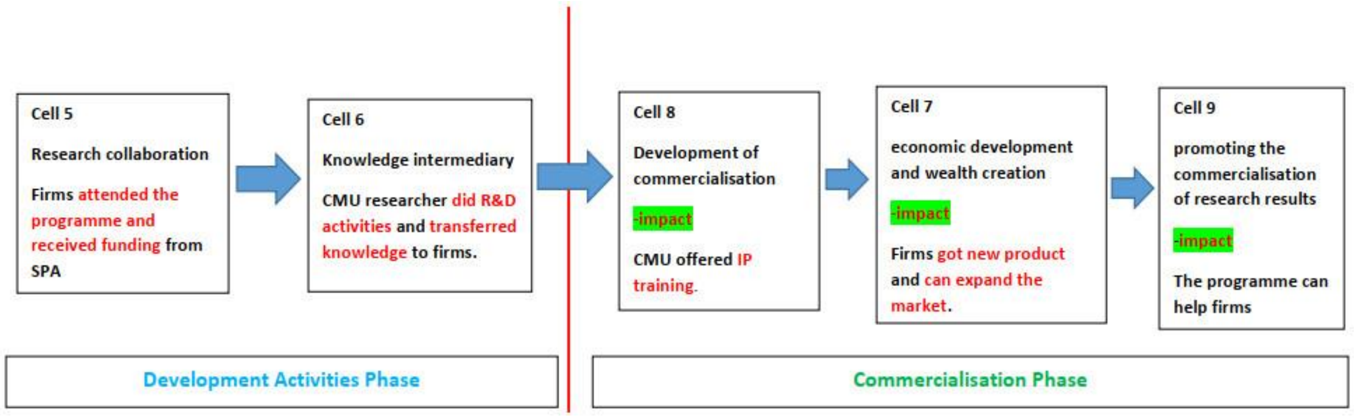
Universities are considered as the key component and knowledge producer in the RIS. They play a significant role by linking with firms and other RIS actors to feed their new knowledge into the system. Integrated into the RIS, universities can promote the development of their regions by linking with industry, engaging in patenting and licensing activities, participating in commercialisation activities (contract research and research collaboration), and supporting spin-off firms (Trippl et al., 2015).

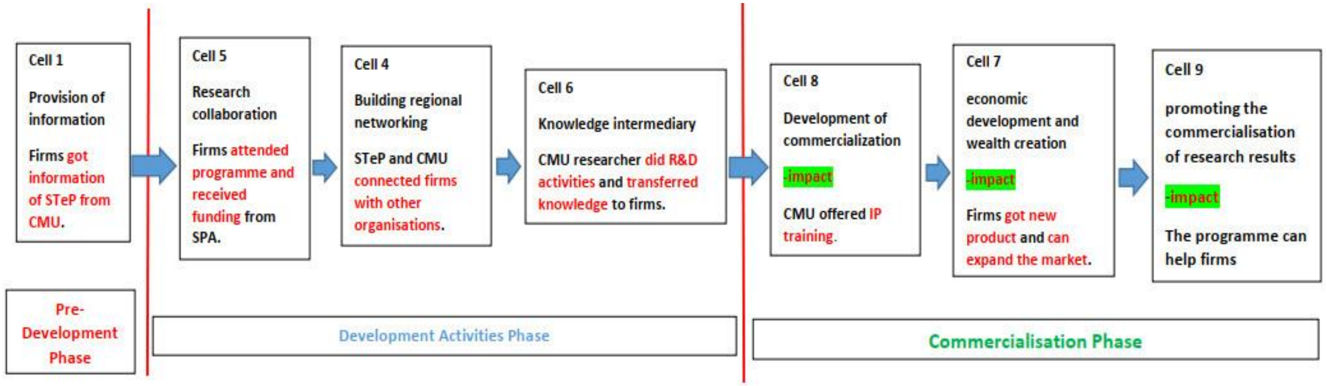
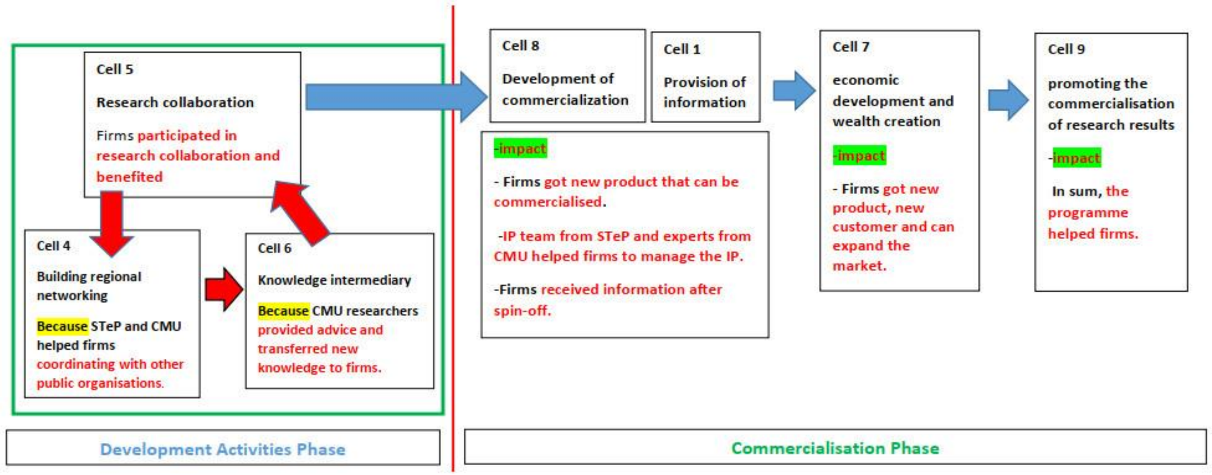
This section, therefore, presents interactive innovation processes that exist within the RIS–university–science park nexus in Northern Thailand and which affect the commercialisation of research results in a specific region of Thailand to answer RQ3a: *'What are the roles of the university in its relationships between the RIS, university and science park actors in innovation projects conducted with on-park firms?'*

As Northern Thailand is considered a peripheral region, this section also illustrates the differences and similarities between the specific NT-RIS and RISs of peripheral regions grasped from literature. Thus, the findings of this thesis contribute to the literature in the sense of providing evidence of an RIS in a peripheral region and developing-economy context.

Table 6.3 summarises the structure of the interactive innovation processes that have been found in this thesis. Analysis of the research data from phase 1 led to the development of four process maps, using the cell structures identified in the critical literature review, with commonalities in content across cases. These four 'aggregate maps' were developed and compared with the interactive innovation process of each case from phase 2, with sequencing identified from across the different cases. This finally revealed how CMU, in its relationships with the other actors in the RIS, which affect the commercialisation of research, is engaged in in four basic sets and sequences of processes in the projects studied between researchers and firms (described below).

TABLE 6.3: THE INTERACTIVE INNOVATION PROCESSES UNCOVERED IN PHASES 1 AND 2

Processes	Quantity (no. of cases)	The structure of the main processes	The characteristics of processes
Research Relationship Process (emphasising cell 5)	**3 cases** (cases 2, 6 and 9)		-The simplest process starting with the pre-development phase through to the commercialisation phase -Emphasised the university's role in research collaboration but without showing the university's role in building regional networks in the development activities phase and the IP management in the commercialisation phase
Product Development Process (emphasising cell 8)	**2 cases** (cases 3 and 10)		-The shortest process starting with the development activities phase through to the commercialisation phase -Emphasised the university's role in IP management but without showing the university's role in building regional networks in the development activities phase - Embedded in both the research relationship process (emphasising cell 5) and the knowledge transfer process (emphasising cell 6)

Knowledge Transfer Process (emphasising cell 6)	**5 cases** (cases 5, 7, 8, 11 and 12)		-The longest process starting with the pre-development phase through to the commercialisation phase - Emphasised the role of the university as a knowledge intermediary
Impact Process (emphasising cell 9)	**2 cases** (cases 1 and 4)		-The most complex process; it focused on the benefits that firms receive from research collaboration with CMU and STeP. -A cycle exists showing why firms benefited from research collaboration

Note: The structures of interactive innovation processes are also provided in a larger format in Appendix 2.

From Table 6.3, four main processes, including the research relationship process (emphasising cell 5), the product development process (emphasising cell 8), the knowledge transfer process (emphasising cell 6) and the impact process (emphasising cell 9) illustrate the 'interactive innovation processes and relationships in a specific NT-RIS' from phase 1 of this thesis. The research relationship process (emphasising cell 5) is the simplest process, starting with the pre-development phase through to the commercialisation phase, and it emphasised the university's role in research collaboration. This process did not show the university's role in building regional networks and IP management, highlighting the difference from other processes. As for the product development process (emphasising cell 8), it is the shortest process, starting with the development activities phase through to the commercialisation phase, which emphasised the university's role in IP management. Additionally, the product development process did not illustrate the university's role in building regional networks. In the case of the knowledge transfer process (emphasising cell 6), it is the longest process, starting with the pre-development phase through to the commercialisation phase and emphasised the university's role as a knowledge intermediary. Lastly, the impact process (emphasising cell 9) is the most complex process, focusing on the 'benefits' firms receive from participating in research collaboration with CMU and STeP.

To identify how CMU and the relationships between actors in the RIS affected the commercialisation of research results in projects between researchers and firms, the innovation process of each case study from phase 2 was matched with the four processes from phase 1, aiming to see which process was compatible in each case study. The findings are provided below.

6.3.1 Research relationship process (emphasising cell 5)

This process focuses on the collaboration of firms and CMU researchers within each project. It starts with the pre-development phase through to the commercialisation phase (Figure 6.2) illustrating the simplest process. Interestingly, the university's roles in terms of building regional networks and providing IP services were not observed in this process.

From the evidence of phase 2, the interactive innovation processes of three cases (cases 2, 6 and 9) are compatible with this process.

FIGURE 6.2 RESEARCH RELATIONSHIP PROCESS (EMPHASISING CELL 5)

Cell 1

Provision of information (knowledge co-creation + Resource Sharing)

-Providing information

"Before attending the programme, I received information of STeP from CMU researcher." (OPF3)

Cell 5

Research collaboration

(Conduit + Brokerage Role)

- Research collaboration

"I attended [the] IRTC programme of STeP that collaborated with CMU. Participated in the programme, I received funding from government agency for doing my project." (OPF3)

Cell 6

Knowledge intermediary

(Inter-organisational relations + Brokerage Role)

-Process of knowledge intermediary

"Then, STeP coordinated with CMU and selected [a] researcher to help me [with] developing new products. When I faced with the problems in manufacturing procedure or problems in machinery, I contacted STeP, then, it sent the experts from [the] Faculty of Engineering of CMU to help me solving problems and transferring new knowledge to me." (OPF3)

"I had a meeting with the researcher who guided me [on] how to conduct R&D activities for my business. The researcher also transferred additional knowledge to me." (SOF4)

Cell 7

Economic development and wealth creation (knowledge co-creation + Exploitation and Commercialisation)

-Impact

-New product

"I will get the new product, which is the result from research collaboration, for my business." (OPF 3)

"I got [a] new product and it can be commercialised." (SOF4)

Cell 9

Promoting the commercialisation of research results (Inter-organisational relations + Exploitation and Commercialisation)

-Impact

"The programme helped me very much. After [the firm] graduated from the programme, I got [a] new product and research results to claim the quality of [the] product. Participated in the programme, the waste from my business was added-value and it can be commercialised." (SOF4)

Pre-Development Phase

Development Activities Phase

Commercialisation Phase

As some firms and CMU researchers worked together on prior projects and they had a 'strong personal relationship' before attending the STeP programme, the firms and researchers kept in contact and shared information for the new project. This process hence started from the firms receiving information about the STeP programme from the researcher in the pre-development phase, for example: *'Before attending the programme, I received information of STeP from [the] CMU researcher'* (OPF3).

After that, firms participated in the STeP programme. SPA/MOST provided funding to firms to undertake the project. In some cases, STeP and CMU selected the potential researchers to work on the firms' projects. Then, the researchers started their role as a knowledge intermediary by searching for new knowledge related to the project or to solve the firms' problems and finally transferring that knowledge to the firm. The following quote illustrates the process and relationships between the actors:

'I attended [the] IRTC programme of STeP that collaborated with CMU. [I] Participated in the programme, I received funding from [the] government agency for doing my project. Then, STeP coordinated with CMU and selected [a] researcher to help me [with] developing new products. When I [was] faced with problems in [the] manufacturing procedure or problems [with the] machinery, I contacted STeP, then it sent researchers to help me solve [the] problems and transfer new knowledge to me.' (OPF3)

This then led to the commercialisation phase. The process showed that firms would receive the new product from the research collaboration that could be commercialised: *'I will get the new product, which is the result from [the] research collaboration, for my business'* (OPF 3). Also, during an interview with a spin-off firm, one participant stated: *'I got [a] new product and it can be commercialised'* (SOF4).

Finally, the process ended with the firm rating the STeP programme and CMU in terms of helping the firm to promote the commercialisation of research results:

'The programme helped me very much. After [I] graduated from the programme, I got [a] new product and research results to claim the quality of [the] product. [I] Participated in the programme; the waste from my business was added-value and it can be commercialised.' (SOF4)

The process can start again as a loop when the firms and researchers start another new project.

From phase 2, the research relationship process (emphasising cell 5) was identified as a process common to more successful (case 6) and less successful projects (cases 2 and 9). As the processes of these cases showed that the researchers did not collaborate with other RIS actors and the firms did not attend CMU's IP training, this highlights the nature of the research relationship process (emphasising cell 5).

6.3.2 Product development process (emphasising cell 8)

This process focuses on the way that university/CMU researchers develop firms' new products for commercialisation. It starts with the development activities phase to the commercialisation phase (see Figure 6.3), highlighting the shortest process which is embedded between the knowledge transfer process (emphasising cell 6) and the research relationship process (emphasising cell 5). The roles of the university to provide IP services or IP management (development of commercialisation) to firms are combined in the process. The university's role in building regional networks was not observed. From the evidence from phase 2, the interactive innovation processes of two cases (cases 3 and 10) were compatible with this process.

FIGURE 6.3 PRODUCT DEVELOPMENT PROCESS (EMPHASISING CELL 8)

Cell 5

Research collaboration

(Conduit + Brokerage Role)

-Programmes of research collaboration

"STeP and CMU had collaboration platforms or the programme that offered additional funding from SPA/MOST to firms and helped firms launching new products." (OPF3)

"I attended the programme of STeP and CMU. I received additional funding from SPA to develop my new product." (SOF4)

Cell 6

Knowledge intermediary

(Inter-organisational relations + Brokerage Role)

-Development of commercialisation (HOW) (launching the new product) and the impact

"After that, my new products were developed and improved by [the] researcher who did R&D activities, designed [the] new packaging for my product, and tested the developed machinery in my production line. The researcher also transferred the knowledge from [the] project to me." (OPF3)

Cell 8

Development of commercialisation

(Conduit + Exploitation and Commercialisation)

-Impact

- IP management

"STeP/CMU provided experts from [the] university to guide me registering the patent. Also, CMU offered IP training for both on-park and spin-off firms." (OPF3)

Cell 7

Economic development and wealth creation

(knowledge co-creation + Exploitation and Commercialisation)

-Impact

-New product

"I will get the new product, which is the result from research collaboration, for my business." (OPF3)

-Expanding the market

"I can expand the market." (SOF4)

Cell 9

Promoting the commercialisation of research results

(Inter-organisational relations + Exploitation and Commercialisation)

-Impact

"The programme can help me. My business has been accredited because it was nurtured by the public organisations and [the] university. Customers will trust in my product due to [the fact that] it came from research results of the outstanding university in Thailand." (OPF3)

Development Activities Phase

Commercialisation Phase

The STeP programme normally involved the collaboration between STeP and CMU to allow CMU researchers to undertake projects with on-park firms. This process starts with firms attending the STeP programme that offered additional funding from SPA/MOST: *'I attended the programme of STeP and CMU. I received additional funding from SPA to develop my new product'* (SOF4).

Then, the researchers acted as a knowledge intermediary by performing R&D activities and transferring knowledge to the firms during the development activities phase. The following quote illustrates this role:

'My new products were developed and improved by [a] researcher who did R&D activities, designed [the] new packaging for my product, and tested the developed machinery in my production line. The researcher also transferred the knowledge from [the] project to me.' (OPF3)

After that, the process led to the commercialisation phase in which the firms received IP services, including IP management consulting and IP training, from STeP and CMU:

'STeP/CMU provided experts from [the] university to guide me registering the patent. Also, CMU offered IP training for both on-park and spin-off firms.' (OPF3)

Finally, firms received their new product and could expand their market. They rated the outcome of the STeP programme and CMU in terms of promoting the commercialisation of research results: *'The programme can help me. My business has been accredited because it was nurtured by [a] public organisation and university. Customers will trust my product due to [the fact that] it came from research results of the outstanding university in Thailand'* (OPF3).

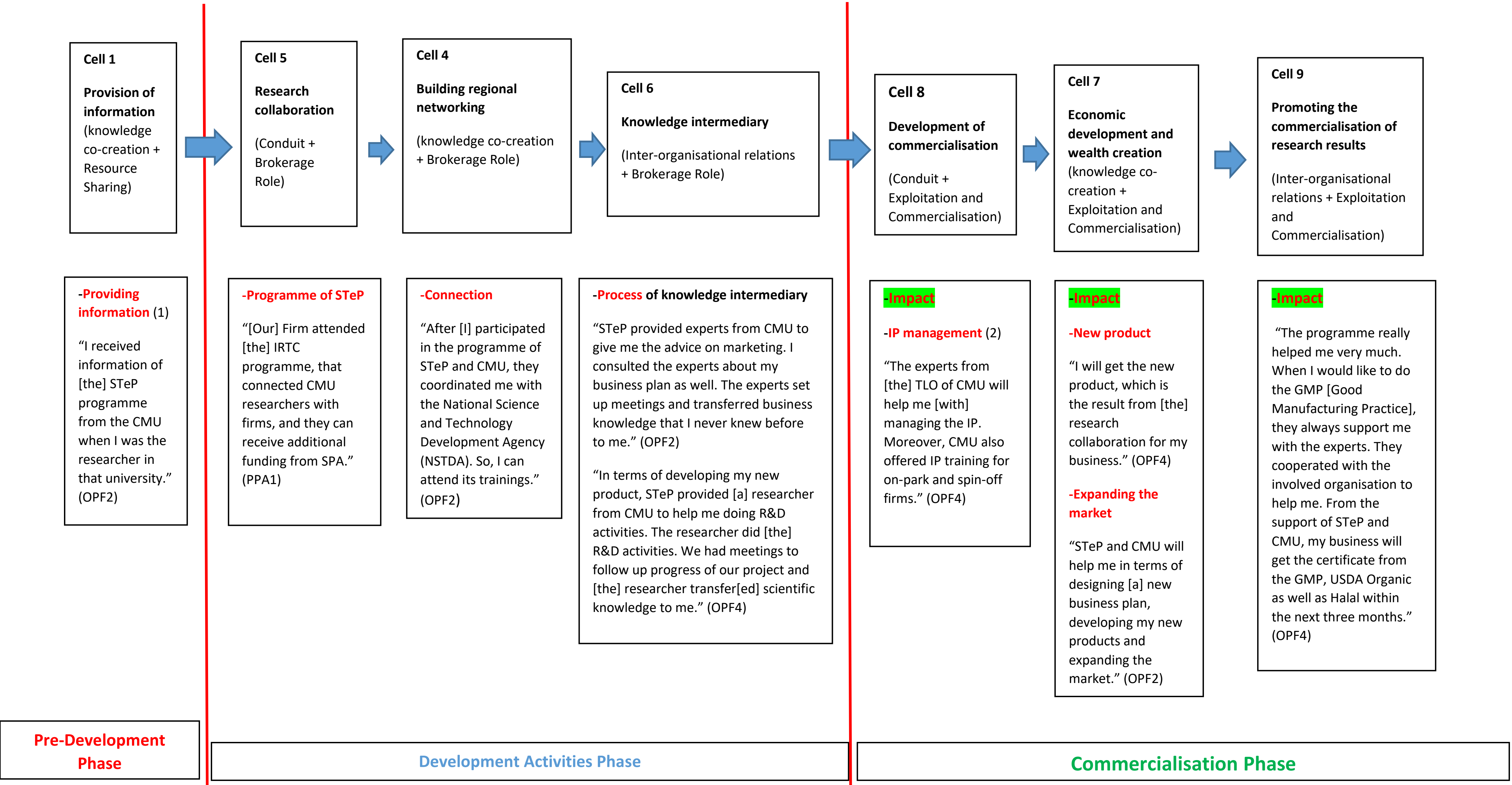
From the evidence of phase 2, the product development process (emphasising cell 8) was evident in both successful (case 3) and less successful projects (case 10). As the processes of these cases showed that the researchers did not collaborate with other RIS actors, this highlighted the nature of the product development process (emphasising cell 8).

6.3.3 Knowledge transfer process (emphasising cell 6)

The knowledge transfer process (emphasising cell 6) is the longest process, starting with the pre-development phase through to the commercialisation phase. It concerns how the knowledge transfers from the university to the firm (see Figure 6.4), especially through the role of knowledge intermediary, where CMU researchers search for new knowledge and transfer it to firms. Moreover, the university's role in building an RIS network is a component of this process.

From the evidence in phase 2, the interactive innovation processes of five cases (cases 5, 7, 8, 11 and 12) were compatible with this process, making it the process which was most strongly followed in terms of numbers of firms, which is unsurprising given the evidence used in exploring RQ2.

FIGURE 6.4 KNOWLEDGE TRANSFER PROCESS (EMPHASISING CELL 6)



As a process, some firms and CMU researchers worked together on prior projects before attending the STeP programme. They kept in contact and the firms received information about the STeP programme from PR (Public Relations) or the CMU researcher during the pre-development phase. In some cases, staff from the firms were prior researchers at CMU and they received information about the STeP programme from the university: *'I received information of [the] STeP programme from the CMU when I was the researcher in that university'* (OPF2).

After that, firms attended the STeP programme and they received additional funding from SPA/MOST. In some cases, STeP matched a CMU researcher with firms to undertake the project: *'[the] Firm attended [the] IRTC programme, that connected CMU researchers with firms, and they can receive additional funding from SPA'* (PPA1).

The researchers then contacted experts from different universities/organisations to participate in the project to share knowledge/ideas. In some cases, STeP and CMU connected with other RIS actors aiming to transfer knowledge to the firm. The following quote illustrates this process:

'After [I] participated in [the] programme of STeP and CMU, they coordinated me with the National Science and Technology Development Agency (NSTDA). So, I can attend its training.' (OPF2)

This process also highlighted the role of CMU as a knowledge intermediary in that the researchers searched for additional knowledge and then transferred it to firms. The following quote indicated this role:

'The researcher did R&D activities. We had meetings to follow up [the] progress of our project and [the] researcher transfer[ed] scientific knowledge to me.' (OPF4)

Next, the process led to the commercialisation phase and illustrated the benefits firms received from attending the STeP programme (e.g., firm benefit from the IP service, receive new products and can expand their markets). OPF4 stated that *'The experts from TLO of CMU will help me manage the IP. Moreover, CMU offered IP training for on-park and spin-off firms. After that, I will get new product, which is the result from [the] research collaboration.'*

Finally, the process ended with the firm rating the STeP programme and CMU in terms of helping the firm to promote commercialisation of the research results: *'The programme really helped me very much'* (OPF4). The process could be started again if the firms and researchers work together on another project.

The knowledge transfer process (emphasising cell 6) was embedded in most cases of phase 2. Hence, both more successful projects (cases 8, 11 and 12) and less successful projects (cases 5 and 7) exhibited this process. Interestingly, all firms in these projects had a strong relationship with CMU after spin-off.

6.3.4 Impact process (emphasising cell 9)

The impact process (emphasising cell 9) (see Figure 6.5) is the process focusing on the benefits firms receive from attending the STeP programme or attending research collaborations with STeP and CMU researchers. It is the most complex process, starting with the development activities phase, which has the embedded cycle, through to the commercialisation phase.

From the evidence in phase 2, the interactive innovation processes can be seen to describe only two of the cases (cases 1 and 4). While this is surprising given the likely fledgling nature of the RIS and the need for capacity building in the firms involved, it does also offer some grounds for optimism for the future.

Figure 6.5 Impact process (emphasising cell 9)

Cell 5

Research collaboration

(Conduit + Brokerage Role)

-Impact

"[I] Participated in the research collaboration, my recent product will be developed, approved, and supported by [an] academic researcher, public organisation and the university." (OPF3)

"[I] Participated in the programme, I received additional funding from [a] government agency and got knowledge to do the business." (OPF2)

Cell 4

Building regional networking

(knowledge co-creation + Brokerage Role)

-Connection WHY

"Because B2G is the coordination with government. Hence, the links with STeP, which is the public organisation, and CMU, which is the famous university, can make me easily connect with other firms and organisations." (OPF2)

"SteP and CMU can help me coordinate with the other public organisations." (OPF3)

Cell 6

Knowledge intermediary

(Inter-organisational relations + Brokerage Role)

-Process of knowledge intermediary WHY and HOW

"As STeP collaborated with CMU to support me, the university then provided experts who always gave me the advice and they transferred new knowledge to me." (OPF2)

Cell 8

Development of commercialisation

(Conduit + Exploitation and Commercialisation)

-Impact

"I will get the new channels to commercialise my new products by launching at [an] international fair that [was] recommended by STeP and CMU. Also, [the] IP team from STeP and the experts from [the] Technology Licensing Office (TLO) in CMU will help me to manage the IP." (OPF2)

"I will receive additional information relevant to new programmes or trainings of STeP and CMU after spin-off." (OPF3)

Cell 1

Provision of information

(knowledge co-creation + Resource Sharing)

Cell 7

Economic development and wealth creation

(knowledge co-creation + Exploitation and Commercialisation)

-Impact

-New product

"The programme of STeP and CMU can help on-park firms developing new products and they can sell them." (UPE1)

-New customer

"Further, some spin-off firms can receive new customers." (UPE1)

-Expanding the market

"The programme can help me [with] designing [a] successful business plan and I could expand the market." (OPF3)

Cell 9

Promoting the commercialisation of research results

(Inter-organisational relations + Exploitation and Commercialisation)

-Impact

"The programme helped me very much, particularly, in this phase, that I am conducting the research and trying to make the research results to be commercialised." (OPF2)

"The programme helped me very much." (OPF3)

Development Activities Phase

Commercialisation Phase

The process started with the development activities phase; firms participated in the STeP programme, benefited from funding as well as received knowledge: *'I received additional funding from [the] government agency and got [the] knowledge to do the business'* (OPF2).

After that, the process illustrated the benefits firms received from participating in the STeP programme as a cycle (starting with the connection to STeP and CMU and then to the role of CMU as a knowledge intermediary). The following quote reveals the benefits:

'Because B2G (Business to Government) is the coordination with government. Hence, the links with STeP, which is the public organisation, and CMU, which is the famous university, can make me easily connect with other firms and organisations…As STeP collaborated with CMU to support me, the university then provided experts who always gave me the advice and they transferred new knowledge to me.' (OPF2)

These also highlighted the reasons why firms participate in the STeP programme.

The impact process then led to the commercialisation phase, in which firms benefited from IP services after spin-off from the programme: *'[the] IP team from STeP and experts from TLO of CMU will help me to manage the IP'* (OPF2).

At the same time, firms obtained additional information:

'I will receive additional information relevant to new programmes or training of STeP and CMU after spin-off.' (OPF3)

The process showed that firms benefit from getting new products and customers. They could also expand their markets. The process finally ended with the firms rating the STeP programme in terms of helping them to promote commercialise the research results: *'The programme helped me very much'* (OPF3).

From phase 2, the innovation process of cases 1 and 4 were compatible with this process. As firms from these cases can commercialise their products from the STeP programme both in Thailand and international countries, the impact process, therefore, was the process of successful projects, where firms had strong relationships with CMU even after spin-off.

6.3.5 How the university contributes to the innovation activities of on-park firms in the context of a peripheral region developing economy: Identification of success-driving factors

The findings of this thesis also allowed innovation success-driving factors to be identified that can be used to answer RQ3b: *'How does the university contribute to the innovation activities of on-park firms in the context of a peripheral region developing economy?'* (see Table 6.4).

TABLE 6.4: THE SUCCESS-DRIVING FACTORS AGAINST FOUR MAIN PROCESSES

Cells	Success-driving factors	Four main processes											
		Research relationship process (emphasising cell 5)			Product development process (emphasising cell 8)		Knowledge transfer process (emphasising cell 6)					Impact process (emphasising cell 9)	
		case 2	case 6	case 9	case 3	case 10	case 5	case 7	case 8	case 11	case 12	case 1	case 4
Cell 4	Attending training				X	X				X	X	X	X
	Participating in a formal programme	X	X				X	X	X	X	X	X	X
Cell 5	Joint research projects (with other RIS actors)						X	X	X	X	X	X	
Cell 6	Knowledge Intermediaries	X	X	X	X	X	X	X	X	X	X	X	X
Cell 7	Having a 'strategy' to encourage researchers to produce research results that meet with the needs of industry	X	X	X	X	X	X	X	X	X	X	X	X
Cell 8	Attending IP training				X	X				X	X	X	X
	Outcome												
Cell 9	Researchers/firms rated the outcome to be highly successful.		X		X				X	X	X	X	X

From Table 6.4, researchers and firms from seven cases (cases 1, 3, 4, 6, 8, 11 and 12) rated the outcome of their projects to be highly successful. The success-driving factors most strongly associated with this outcome, relative to their association with those rating the outcome as less than highly successful, are indicated as follows:

1) Cell 4: Firms attended CMU training and some of them also participated in CMU's formal programme (e.g., AS programme etc.) and those of other organisations before attending the STeP programme. Consequently, they were able to build regional networks with CMU researchers who could help them to develop the new products/machine/packaging.
2) Cell 5: In some projects (cases 1, 8, 11 and 12), CMU researchers contacted other experts in Northern Thailand to participate in the research collaboration. Hence, they shared knowledge and ideas, making their projects successful.
3) Cell 8: CMU provided IP training to firms in a specific NT-RIS. Findings of this thesis show that firms from successful projects (cases 1, 3, 4, 6, 8, 11 and 12) attended IP training more than those from less successful projects.

Researchers also undertook R&D activities and transferred new knowledge to firms in all the projects. Therefore, researchers acted as knowledge intermediaries and firms also benefited from this role, but this was not something that can be seen as specifically driving more successful projects. Similarly, CMU has a 'strategy' to encourage researchers to produce research results that meet the needs of industry. Thus, CMU researchers who participated in the STeP programmes undertook R&D activities to develop new products/machine/packaging for firms.

6.3.6 Summary and identification of contributions

This section presented four processes illustrating the roles of CMU and its relationships with RIS actors. Hence, it allowed key activities to be identified and emphasised the roles being performed by the university within the emerging NT-RIS to answer RQ3a. The four broad processes were then compared with the interactive innovation processes of each case study in phase 2 to identify, for each case study/project, which broad process it was closest to. This revealed how CMU played certain roles to support firms and the 'characteristics' of four processes, as well as project outcomes. Given the dearth of literature examining these processes in the specific context of the RIS–university–science park nexus, this represents a contribution to knowledge both generally and specifically in the context of a developing peripheral economy.

Firstly, the processes of three cases (cases 2, 6 and 9) were compatible with the research relationship process (emphasising cell 5), which was focused on the role of the university in research collaboration. Interestingly, the university's roles in building RIS networks (cell 4) and developing commercialisation in terms of IP services (cell 8) were not found in all three cases. As for project outcomes, both firms in cases 2 and 9 have still not launched their new product because the duration of the STeP programme was too short (case 2) and the firm (case 9) has been looking for an OEM. The firm in case 6 used the developed oven in its production, and the developed oven can help the firm save production costs. In sum, the research relationship process (emphasising cell 5) occurred in both more successful (case 6) and less successful (cases 2 and 9) projects.

Secondly, the innovation processes of two cases (cases 3 and 10) were compatible with the product development process (emphasising cell 8), which focused on developing commercialisation through the IP service. The processes of the two cases started with the development activities phase through to the commercialisation phase and showed that the firms attended CMU's IP training (cell 8) after spin-off. However, CMU's role in building an RIS network (cell 4) did not appear in the processes. As for the project outcome, both firms still have not commercialised their products because one firm (case 3) has been looking for an OEM, while the other (case 10) preferred to develop the packaging for the new product themselves. In conclusion, the product development process (emphasising cell 8) was evident in both successful (case 3) and less successful (case 10) projects.

Thirdly, the knowledge transfer process (emphasising cell 6) was compatible with the process of five cases (cases 5, 7, 8, 11 and 12) and demonstrated the full process of how knowledge transferred from the researcher to the firm. The outcomes of the projects in cases 8, 11 and 12 are more successful when compared with those of cases 5 and 7. The firm in case 8 launched its new product in Thailand, and both firms in cases 11 and

12 launched their product in Thailand as well as presented the products in international countries. The firms in cases 5 and 7 have not launched their new products due to the fact that they were not finished at the end of the STeP programme. Therefore, the knowledge transfer process (emphasising cell 6) was evident in both more successful (cases 8, 11 and 12) and less successful (cases 5 and 7) projects.

Lastly, the process of two cases (cases 1 and 4) were compatible with the impact process (emphasising cell 9), which focused on the benefits firms gained from attending the STeP programme. Firms in both cases benefited from the full services of CMU and STeP. Interestingly, they still kept in contact with the researchers after spin-off. The outcomes of their projects were more successful because the products can be commercialised both in Thailand and internationally. In sum, the impact process (emphasising cell 9) was demonstrated as a process of successful projects (cases 1 and 4).

From the findings of this thesis, there are four types of interactive innovation processes occurring within the RIS–university–science park nexus that affect the commercialisation of research results in a specific region of Thailand: the research relationship process (emphasising cell 5), the product development process (emphasising cell 8), the knowledge transfer process (emphasising cell 6) and the impact process (emphasising cell 9). By comparing the interactive innovation processes among actors in a peripheral RIS of developed-economy countries with the findings of this thesis, the result will identify the differences and similarities between the roles of actors in peripheral RISs of developed-economy countries and those of Thailand (see Table 6.5). Therefore, the findings of this thesis can contribute to the literature.

TABLE 6.5: COMPARISON BETWEEN THE INTERACTIVE INNOVATION PROCESSES IN PERIPHERAL RISS FROM THE LITERATURE AND THOSE FROM THE FINDINGS OF THIS THESIS

	Evidence from existing literature		The findings of this thesis	Contribution of this thesis
Innovative innovation processes	Beauce (Canada)	-Firms collaborated with others and linked with universities and research institutions located 'outside' Beauce to develop innovation. - SMEs are strong in incremental innovation but less developed in product development (Doloreux, 2003). - The process sequence started with firms collaborating with other actors (cell 5), building regional networks (cell 4), then receiving new knowledge (cell 6) and, finally, they innovated or they can commercialise new products (cell 7).	-Firms collaborated with the university and science park located in the same region. -Firms and CMU researchers (cases 3, 4, 8, 9 and 10) created new products, highlighting they are robust in product development.	-Evidence from this thesis did not support the evidence in the literature because firms did not collaborate with other firms, universities and research institutions located outside the region and firms are strong in product development. -The knowledge transfer process sequence (emphasising cell 6) is similar to those from the literature but without the science park being involved in the process.
	Scotland (UK)	-Adria worked with the IRTU and other regional firms to innovate in clothing (Cooke, Roper, et al., 2003). - The process sequence started with the firm participating in the Research and Technology Unit (cell 5) and collaborating with other regional firms (cell 4), then the firm received knowledge (cell 6) and a new product (cell 7), has then been innovated (cell 9).	-Firms collaborated with CMU and STeP, but they did not work with other regional firms to innovate.	-Evidence from this thesis did not support the evidence in the literature because firms did not work with other regional firms to innovate. -The knowledge transfer process sequence (emphasising cell 6) is similar to those from the literature but without the science park being involved in the process.

Interactive innovation processes	Quebec's coastal region (Canada)	-Technology transfer organisations have the role of 'solving day-to-day operational problems', some institutions supported the commercialisation and innovation processes of small firms; the region also has limited organisations from outside participating in innovation projects (Doloreux et al., 2009). - The process sequence started with firms collaborating with TTOs to undertake projects or 'receive services' (cell 5), then they received knowledge from the technology transfer (cell 6) and innovate in the commercialisation phase (cell 7 and 9).	-STeP and CMU researchers have the role of helping firms to solve problems in their business; STeP and CMU also encouraged the commercialisation of research results and supported firms' innovation processes. -A limited number of organisations from outside the region participated in the collaborative projects.	-Evidence from this thesis supports evidence in the literature. -The research relationship process sequence (emphasising cell 5) is similar to that from the literature but without the science park being involved in the process.
	La Pocatière (Canada)	-The interactive innovation process is focused on developing solutions and incremental innovations. -Firms are not engaged in R&D activities and they focused on product development. -Three types of interaction between private–public organisations are observed, including inter-institutional collaborations between local organisations, co-operation between firms, and collaboration between firms and local public organisations (Doloreux & Dionne, 2008). - The process sequence started with firms collaborating to develop the products (cell 5), then they obtained knowledge from the technology transfer (cell 6) and then innovate (cell 9).	-The interactive innovation process in a specific NT-RIS included solutions, developing incremental innovations and product development.	-Evidence from this thesis supports evidence in the literature. -The research relationship process sequence (emphasising cell 5) is similar to those from the literature but without the science park being involved in the process.

Innovative innovation processes	Styria (Austria)	-Technical University undertook a project to support technology transfer, in which 70 firms were selected to initiate co-operations (Tödtling & Sedlacek, 1997). - The process sequence started with firms participating in the 'specialist programme' to undertake a project or to 'receive services' (cell 5), then firms obtained knowledge from the technology transfer (cell 6) and they are innovated in the commercialisation phase (cell 7 and 9).	-CMU provided academic services to firms in the region to collaborate on projects and support technology transfer; CMU also cooperated with STeP to offer researchers to participate in projects with on-park firms.	-Evidence from this thesis supports evidence in the literature. -The research relationship process sequence (emphasising cell 5) is similar to those from the literature but without the science park being involved in the process.
	La Pocatière (Canada)	-Premier Tech biotechnology initiated collaborations with research centres in both Europe and South America for data and experiments; it also exchanged information and improved knowledge in the process of certification (Doloreux & Dionne, 2008). - The process sequence started with firms collaborating with research centres (cell 5) in international countries (cell 4) and then receiving knowledge (cell 6). After that, the firm can exchange information (cell 1) and innovate (cell 9).	-Firms in the NT-RIS did not collaborate with research centres outside the country.	-Evidence from this thesis did not support evidence in the literature because firms did not collaborate with research centres outside the country. -However, the impact process sequence (emphasising cell 9) is similar to those from the literature but without the science park being involved in the process.

According to Doloreux (2003), most firms in Beauce – a peripheral region in Quebec, Canada – collaborated with other firms, as well as linked with universities and research institutions outside Beauce to develop innovations. Moreover, SMEs in this region are strong in incremental innovation but less so in terms of product development. In comparison, the studied firms in the NT-RIS collaborated with the university and science park located in the same region; in some cases (cases 3, 4, 8, 9 and 10), firms and CMU researchers creating new products highlighting that they are robust in product development. Hence, the interactive innovation process in Beauce is different from those in the specific NT-RIS. By comparing the interactive innovation process in Beauce with the four types of interactive innovation processes found in this thesis, it showed that the process sequence is similar to the knowledge transfer process (emphasising cell 6) because firms collaborated with other actors (cell 5), built regional networks (cell 4), then received new knowledge (cell 6), and, finally, they innovated or can commercialise new products (cell 7). Moreover, this process showed that the firms built 'regional networks' with other firms (cell 4), illustrating the nature of the knowledge transfer process (emphasising cell 6). Interestingly, IP management (cell 8) did not appear in this process, emphasising that it has been neglected in this peripheral RIS.

With respect to Cooke et al. (2003), Adria, the firm in the RIS in Scotland, worked with the IRTU and other regional firms to innovate in clothing. This process is similar to the sequence of the knowledge transfer process (emphasising cell 6) due to the firm starting by participating in the Research and Technology Unit (cell 5) and collaborating with other regional firms (cell 4), then receiving knowledge (cell 6) and obtaining a new product (cell 7), and innovation (cell 9). As this process illustrates that the firm built 'regional networks' with other firms (cell 4), it highlighted the nature of the knowledge transfer process (emphasising cell 6). In addition, IP management (cell 8) did not appear in this process, highlighting that it has been neglected in peripheral RISs. Comparing the interactive innovation process of Adria with the findings of this thesis, the result shows that firms in the NT-RIS did not collaborate with other regional firms for innovating. This emphasises the difference.

As seen in the case of the aquaculture industry innovation system of Quebec's coastal region (in Canada), technology transfer organisations played the role of 'solving day-to-day operational problems', some institutions supported the commercialisation and innovation processes of small firms, and the region had limited external organisations participating in innovation projects (Doloreux et al., 2009). Similarly, STeP and CMU researchers have the role of helping firms solve problems in their business. Both of them encouraged firms' commercialisation and innovation processes. Also, a limited number of organisations from outside the region participated in the collaborative projects.

With respect to Doloreux and Dionne (2008), the interactive innovation process of La Pocatière (in Canada) is focused on 'solutions and developing incremental innovations rather than being research intensive'. In this region, a lot of firms are not engaged in R&D activities and they focus on product development. Similarly, the interactive innovation process in a specific NT-RIS includes solutions and developing incremental innovations and product development.

Evidence from the Styria RIS (in Austria) indicated that the Technical University initiated a project to support technology transfer in which 70 firms were selected to initiate cooperation (Tödtling & Sedlacek, 1997). In comparison, CMU provided academic services to firms in the region to undertake collaborative projects; it also cooperated with STeP to offer researchers to participate in projects with on-park firms. Thus, CMU operated similarly to the Technical University.

When comparing the interactive innovation processes of the RIS of Quebec's coastal region, La Pocatière and Styria, with the four types of interactive innovation processes found in this thesis, it can be seen that firms in all of these three regions followed the research relationship process sequence (emphasising cell 5) because they participated in a 'specialist programme' to undertake a project or 'receive services' (cell 5). The firms then obtained knowledge from technology transfer (cell 6), innovating in the commercialisation phase (cell 7 and 9). Interestingly, firms in these two processes did not build regional networks (cell 4) and did not receive IP services (cell 8). This supports the nature of the research relationship process (emphasising cell 5).

According to Doloreux and Dionne (2008), they explored an RIS in La Pocatière (Canada) and illustrated that Premier Tech biotechnology initiated a lot of collaborations with research centres in both Europe and South America for data and experiments, as well as exchanged information and improved knowledge of the certification process. The sequence of this process is similar to the impact process (emphasising cell 9) because the firm collaborated with research centres (cell 5) in international countries (cell 4) and then received knowledge (cell 6). As the process demonstrated the 'benefits to firm from collaboration' – for example, firms can exchange information (cell 1), obtain research results from experiments for commercialisation (cells 7 and 9) and improve knowledge in the process of certification – it emphasises the nature of the impact process (emphasising cell 9). Interestingly, IP management (cell 8) did not appear in this process, supporting that it is neglected in peripheral RISs. Comparing the interactive innovation process of Premier Tech biotechnology with the findings of this thesis, the results show that firms in a specific NT-RIS did not collaborate with research centres outside the country, which illustrates a difference.

Prior studies (e.g., Cooke, Roper, & Wylie, 2003; Doloreux, 2003; Doloreux & Dionne, 2008; Doloreux, Isaksen, Aslesen, & Melançon, 2009; Tödtling & Sedlacek, 1997) did not specifically examine, and only provided the limited insights into, interactive innovation processes among actors in peripheral RISs in a developed-economy context. In comparison, this thesis examined the insights of interactive innovation processes both in detail and within the context of a peripheral RIS of a developing-economy country, highlighting the contribution of this specific context to the RIS literature. Furthermore, this thesis identified the success-driving factors to answer RQ3b, which is how the university contributes to on-park firms in the context of a peripheral region developing economy. From the findings, some researchers and firms rated the outcome of their projects to be highly successful due to these specific factors:

- Firms attended CMU training and/or participated in the formal programmes of CMU and other organisations before attending the STeP programme.
- CMU researchers contacted other experts in Northern Thailand to participate in research collaboration, leading to shared knowledge and ideas, and all researchers acted as knowledge intermediaries.
- CMU provided IP training to firms in a specific NT-RIS.

Comparing these findings with existing literature (e.g., Chen & Kenney, 2007) which very broadly illustrates the roles of the university and its relationship with science park in China, this thesis contributes to the literature through more in-depth study and subsequent identification of the interactive innovation processes among actors. This highlights the ways that the university contributed to on-park firms in a peripheral RIS in a developing-economy context. In sum, the comparison between evidence from the existing literature (both evidence of interactive innovation processes in peripheral RISs of developed-economy countries and evidence of the roles of the university in an RIS of a developing-economy country) and those from the findings of this thesis, illustrates the different types of collaboration and the success-driving factors within the specific context of each country that further emphasises the contribution of this thesis to the literature.

6.4 How the university and science park contribute to the development of a peripheral RIS in a developing economy

Northern Thailand is considered to be a peripheral region in a developing economy. The specific NT-RIS, therefore, could have characteristics both similar and different from RISs of other peripheral regions because of the additional developing-economy context. By comparing the characteristics of peripheral RISs from existing literature with the findings of this thesis, it could contribute to the literature in the sense of providing evidence from the RIS–university–science park nexus within a peripheral region developing-economy context. Therefore, this section presents the findings answering RQ4: *'How do the* *university and science park contribute to the development of a peripheral RIS in a developing economy?'*

6.4.1 Comparison of the results with the literature

First, in the literature, innovation activities in peripheral RISs are usually based on incremental and process innovation. Conversely, the findings of this thesis show that the innovation activities in a specific NT-RIS focused on product development in a number of ways. This is because the input of the university in the RIS has allowed CMU researchers and firms to create new products, as specifically demonstrated in cases 3, 4, 8, 9 and 10 of this thesis.

Secondly, the RISs of peripheral regions in the literature are often weak due to the networks among actors being limited. Similarly, firms in Northern Thailand are currently not interested in cooperating with other actors in the RIS. Also, an overlap in the roles to promote the RIS among government agencies and limited networking among actors in the NT-RIS were observed. In peripheral RISs, firms are also often found to need to form links outside the region. In the case of the specific RIS in Northern Thailand, CMU and STeP played this role, connecting firms with other universities and government agencies located outside the region – though this role is still limited.

Lastly, some peripheral regions are characterised by 'organisational thinness'. The NT-RIS also displays organisational thinness, with most government agencies relevant to supporting the RIS located in Bangkok, the capital city.

In summary, the NT-RIS is emerging and is currently in the developing phase. Perhaps for this reason (and the need to demonstrate initial value), the innovation activities in the NT-RIS have been more developed than those of general peripheral RISs because the creation of new products has been observed. However, the interactions and coherence among actors still seem to be limited.

Prior studies examining RISs in peripheral regions can be seen to have three main groupings. There is the group of studies portraying an 'interactive innovation process' among actors, the group of studies showing ‘specialist forums or specialist organisations/agencies’ which enhanced the interactive innovation process among actors, and the group of studies identifying ‘specialist programmes’ that encouraged the interactive innovation process between actors.

These previous studies of RISs of peripheral regions, however, were conducted in developed-economy countries and focused on the ‘interactive innovation processes’ among actors (see Table 6.5 in section 6.6 of this chapter), the science park not appearing in all interactive innovation processes of these prior studies and interactions within the RIS–university–science park nexus are mainly reported as a phenomenon of RISs in literature focused on core regions. Because the current research shows that, in the case of a specific peripheral region developing economy NT-RIS, the science park (STeP) is one of the key actors, it identifies an interesting capacity building element of the science park in a context previously underexplored. In addition, in comparison to the more limited role of IP management in processes identified in prior studies in peripheral RISs, in this peripheral region developing-economy context this identifies a specific area where support is given in this more specific context. This might suggest, therefore, that in a peripheral region developing-economy context the role of the science park specifically, and the RIS–university–science park nexus are of even more importance in capacity building.

Secondly, prior studies exploring RISs in peripheral regions identified ‘specialist forums or organisations/agencies’ to enhance the interactive innovation process among actors (see Table 6.6). According to Isaksen (2001), for example, a Technology Forum was set up in the RIS of Arendal (a peripheral region of Norway) to act as a ‘support club’ for local industry, a lobby organisation and a ‘meeting place’. In this area, CMU and STeP are also considered as the ‘specialist forum’ in the NT-RIS. With respect to Tödtling and Sedlacek (1997), WIFI is the intermediary organisation in the Styria RIS (in Austria), which provides ‘technology and innovation support’ to firms. From the case of the RIS in Northern Ireland, the IRTU, which is a public agency, has strengthened the links between key actors in the region and international partners (Cooke, Roper, et al., 2003). Similarly, the findings of this thesis illustrate that STeP has been acting as an intermediary organisation in the NT-RIS. It offered various services to connect firms, CMU researchers and other organisations. Therefore, this identifies that similar roles are played in the more specific peripheral region developing-economy context, which might suggest that it is peripherality that is key to this aspect.

Lastly, prior studies have investigated the interactive innovation process and found 'specialist programmes' initiated in the RISs of several peripheral regions (see Table 6.6). For instance, the NT programme was established to support product and process development in Northern Norwegian firms and to enhance the interaction among firms and R&D institutions (Asheim & Isaksen, 1997). CMU and STeP also collaborated to act as a platform for supporting firms in Northern Thailand; in addition, STeP offers 'various programmes' to encourage the interactive innovation processes among actors. This again supports the evidence from literature but in a more specific peripheral region developing-economy context, which suggests peripherality is also key to this aspect.

In summary, therefore, the evidence from this thesis supports that of the existing literature in terms of the roles of supportive elements to encourage the functioning of RISs, but gives an added peripheral region developing-economy context, identifying the potential for science parks to play an additional capacity-building role in this context.

TABLE 6.6: COMPARISON BETWEEN THE SUPPORTIVE ELEMENTS IN PERIPHERAL RISS FROM THE LITERATURE AND THOSE FROM THE FINDINGS OF THIS THESIS

Supportive elements in peripheral RISs	**Evidence from the existing literature**		**The findings of this thesis**	**Contribution of this thesis**
Specialist forum and organisation/ agency	Arendal (Norway)	-A Technology Forum was set up to act as a ‘support club’ for local industry, a lobby organisation and a ‘meeting place’. -The forum triggered cooperation and a learning culture between firms and the technical college, as well as launched a local incubator and local venture capital fund that invests in NTBFs (Isaksen, 2001).	-CMU and STeP are considered as the ‘specialist forum’ in the NT-RIS.	-Evidence from this thesis supports evidence in the literature.
	Styria (Austria)	-WIFI, an intermediary organisation, provided financial subsidies and mediation of cooperation, marketing of new products, as well as ‘technology and innovation support’ or consultancy services focusing on education and training (Tödtling & Sedlacek, 1997).	-STeP acted as an intermediary organisation in the NT-RIS. It offered various services to connect firms, CMU researchers and other organisations.	-Evidence from this thesis supports evidence in the literature.
	Northern Ireland (UK)	-The IRTU was established to strengthen the Northern Ireland science and technology base and the linkages and networking internally among its key players and internationally (Cooke, Roper, et al., 2003).		
Specialist programmes	Northern Norway (Norway)	-The NT programme was set up to offer financial support for products and process development, as well as to strengthen the cooperation between firms and R&D institutions (Asheim & Isaksen, 1997).	-CMU and STeP collaborated to act as a ‘platform’ to support firms in Northern Thailand. STeP also offered various programmes to encourage the interactive innovation processes among actors.	-Evidence from this thesis supports evidence in the literature.
	Scotland (UK)	-The Interface programme was established to facilitate linkages between SMEs and universities (Brown, 2016).		

In the RISs of peripheral regions, the existing literature notes that universities have a fundamental role in interactive innovation processes and this is one element in which they support capacity building. Prior studies show that universities, such as the La Pocatière Collage and Institute of Agri-Food Technology in La Pocatière, The Centre Universitaire des Appalaches in Beauce, the CSP (a small technical college) in Quebec's coastal region and universities in Valencia supplied 'essential training and education' in several of the region's fields (Doloreux, 2002; Doloreux & Dionne, 2008; Doloreux et al., 2009; García-Aracil & De Lucio, 2008). In this respect, CMU provided similar specialist training and education to several actors in the NT-RIS.

Additionally, universities, including the Technical University and Montanuniversität Leoben in Styria (Austria), the Institute of Agri-Food Technology in La Pocatière (Canada) and universities in Valencia, have been found to have started a 'project' or 'innovation service' to support technology transfer in their peripheral RIS (Doloreux & Dionne, 2008; García-Aracil & De Lucio, 2008; Franz Tödtling & Sedlacek, 1997). Again, similarly, the findings of this thesis show that CMU has a programme and 'academic services' to support technology transfer in the NT-RIS by allowing researchers to undertake collaborative projects with firms. In addition, CMU cooperated with STeP to offer CMU researchers to undertake research contracts and R&D activities with firms in STeP programmes. The evidence from this thesis, therefore, supports that of the existing literature, albeit the science park in this area was an additional vehicle for this support.

In the RIS of Tomsk (Russia), universities interact with industry by hosting conferences and exhibitions to exchange information, participate in joint and contract research, as well as cooperate with firms in technology platforms and regional clusters (Pavlova & Burenina, 2016). CMU also hosted conferences and exhibitions to exchange information with actors within the specific NT-RIS, as well as cooperated with firms in regional clusters. In addition, CMU collaborated with STeP to allow researchers to participate in joint research with firms in STeP programmes.

In conclusion, the findings of this thesis support the existing evidence of the roles of universities in peripheral RISs (see Table 6.7), albeit where the science parks offer an additional forum in which to deliver those roles. As CMU collaborated with STeP to allow CMU researchers to participate in research contracts and R&D activities with firms in STeP programmes, this indicates the ‘unique’ characteristics of CMU’s roles that differ from the evidence in the literature because of the science park context.

TABLE 6.7: COMPARISON BETWEEN THE ROLES OF UNIVERSITIES IN PERIPHERAL RISS FROM THE LITERATURE AND THOSE FROM THE FINDINGS OF THIS THESIS

<table>
<tr><th colspan="2">Roles of universities in peripheral RISs observed in the literature</th><th>The findings of this thesis</th><th>Contribution of this thesis</th></tr>
<tr><td>Universities
(Valencia, Spain)</td><td>They offered advisory and technical support, education and training personnel, joint R&D, as well as engaged in contract R&D (García-Aracil & De Lucio, 2008).</td><td rowspan="3">-CMU provided specialist training and education to several actors in the NT-RIS.

-CMU has a programme or ‘academic services’ to support technology transfer in the NT-RIS by allowing researchers to participate in collaborative projects with firms.

-CMU cooperated with STeP and offered CMU researchers to participate in research contracts and R&D activities with firms in STeP programmes.</td><td>- Evidence from this thesis supports evidence in the literature.

-As CMU collaborated with STeP, it indicates the ‘unique’ characteristic of CMU’s roles, which differs from the evidence in the literature.</td></tr>
<tr><td>Technical University and Montanuniversität Leoben
(Stylia, Austria)</td><td>-They supported technology transfer.
- Montanuniversität Leoben has applied research contracts with firms (Tödtling & Sedlacek, 1997).</td><td rowspan="2"></td></tr>
<tr><td>The institute of Agri-Food Technology and the La Pocatière college
(La Pocatière, Canada)</td><td>They encouraged applied research and technological transfer (Doloreux & Dionne, 2008).</td></tr>
</table>

Universities (Tomsk, Russia)	-They hosted conferences and exhibitions to exchange information. -They participated in joint and contract research, as well as cooperated with firms in technology platforms and regional clusters (Pavlova & Burenina, 2017).	-CMU hosted conferences and exhibitions to exchange information with actors in a specific NT-RIS. It cooperated with firms in regional clusters. - CMU collaborated with STeP to allow researchers to participate in joint research with firms in STeP programmes.	

As discussed previously, prior studies have shown that science parks or technology parks do not play a 'key role' in peripheral RISs of developed-economy countries; instead, they are considered as 'separate elements' to support the main actors in the system. For example, the Styrian Technology Park in a peripheral region of Austria acts as an incubator and provides common services including a secretary, telephone, fax, databases and conference rooms (Franz Tödtling & Sedlacek, 1997). In comparison, the findings of this thesis show that STeP has been more active, behaving as an intermediary organisation, connecting CMU researchers, firms and other actors in the specific NT-RIS. STeP's roles can, therefore, be seen to be stronger than the roles of science parks/technology parks in peripheral RISs of developed-economy countries.

Other previous studies indicating interactions within the RIS–university–science park nexus in peripheral RISs of developed-economy contexts show, for instance, that innovation centres were set up in Scottish universities to assist the commercialisation process in Scotland (Brown, 2016). In a peripheral RIS of the ICT industry in Arendal (Norway), Ericsson and a local technical college established a technology park, which offered a supportive programme to stimulate commercialisation of research results from the college (Isaksen, 2001). However, STeP and CMU can be seen to collaborate more closely, acting as key actors to support interactive innovation processes in the NT-RIS. STeP also provides various programmes to encourage the commercialisation of research results. Thus, the interaction within the RIS–university–science park nexus in the NT-RIS is stronger than those from prior studies.

The NT programme in the peripheral RIS of Northern Norway was also found to have encouraged interactive innovation processes between firms and R&D institutions (Asheim & Isaksen, 1997). By comparing the operational processes of the NT programme with the findings of this thesis, the results show that the NT programme is similar to the STeP programme in terms of supporting interactive innovation processes among actors (see Table 6.8). The STeP programme, however, did not offer 'the active follow-up of firms and projects'; instead, it supported spin-off firms by inviting some of them to present their new products at the innovation fairs.

TABLE 6.8: COMPARISON BETWEEN THE NT PROGRAMME AND STEP PROGRAMME

The NT programme in the RIS of Northern Norway (Asheim & Isaksen, 1997)	**The STeP programme in a specific NT-RIS**	**Contribution of this thesis**
1) The operational process started with the selection of firms best oriented towards innovation and with the necessary financial and human resources to undertake project development.	1) The operational process started with the selection of firms to participate in the STeP programme.	The operational process of the STeP programme is similar to that of the NT programme.
2) The programme then provided broad support to firms including financial, advice, and assistance in finding project cooperation partners.	2) Firms signed a contract and received funding from a government agency. Also, they received advice and participated in R&D activities with CMU researchers and other actors in the RIS.	The operational process of the STeP programme is similar to that of the NT programme
3) The programme actively follows up both firms and projects over long time periods, particularly for firms that have several projects running concurrently.	3) Firms, finally, received new products to commercialise. They can present their new products at the innovation fairs.	The operational process of the STeP programme differs from that of the NT programme because the STeP programme does not actively follow up firms and projects. However, STeP supported spin-off firms by inviting some of them to present their new products at the innovation fairs.

In addition to the limited numbers of studies demonstrating interactions within the RIS–university–science park nexus in peripheral RISs of developed economies, the existing literature also suggests that this phenomenon predominantly occurs in the core regions of developing economies. For example, evidence from the RIS of Beijing indicates THU built a science park as an incubator, showing that spin-off firms can help the university to commercialise research results (Chen & Kenney, 2007) and that the science park plays a key role in the RIS in the core region of China. Conversely, CMU and STeP are located in a core area (Chiang Mai) of a peripheral region in a developing economy; the interactions within the RIS–university–science park nexus in this peripheral region context of the RIS in Northern Thailand have developed to be similar to those found in the core region developing-economy context.

From the findings of this thesis, a high level of formality within the RIS–university–science park nexus in the RIS of Northern Thailand has been observed, because the STeP programme is a very formal programme. Often the benefits to firms, however, were derived from more informal relationships which highlight the NT-RIS is still developing. According to Boucher et al. (2003), the engagement of universities in 'peripheral regions' tend to 'institutionalise informal personal relations into formal and strategically planned networks'. Therefore, the findings of this thesis in terms of high level of formality between RIS-university-science park actors in interactive innovation processes are a consequence of the peripheral region-developing economy context and the findings are also consistent with the evidence in literature.

From the literature on RISs, university roles differ between various countries and regions. Because Thailand is considered a developing-economy context, findings related to the roles and interactions of the university in a peripheral RIS of Thailand, in comparison with other developing-economy countries, may also contribute to the literature (see Table 6.9) because of the core region context of many of the extant studies.

TABLE 6.9: COMPARISON BETWEEN THE ROLES OF UNIVERSITIES IN AN RIS OF A DEVELOPING-ECONOMY COUNTRY AND THOSE OF CMU IN A SPECIFIC NT-RIS

<table>
<tr><th colspan="2">Roles of universities in the RIS of a developing-economy country (China) from the literature</th><th>The roles of CMU from the findings of this thesis</th><th>Contribution of this thesis</th></tr>
<tr><td>Jiao, Zhou, Gao, & Liu (2016)</td><td>The university supports regional innovation through the production of ‘deliverable innovation’ for commercialisation.</td><td>CMU offered academic services to firms in Northern Thailand for producing innovation. Then, firms can commercialise their new products from collaborative projects with CMU researchers in the market.</td><td>Evidence from this thesis supports evidence in the literature.</td></tr>
<tr><td>Asheim & Vang (2011)</td><td>In Shanghai’s RIS, local universities are increasingly involved in research collaboration with firms.</td><td rowspan="2">CMU cooperated with STeP (science park) to serve firms in Northern Thailand through various services of STeP programmes, such as participating in R&D activities, offering consulting services, and providing training and laboratory testing.</td><td rowspan="2">Evidence from this thesis supports evidence in the literature.</td></tr>
<tr><td>Chen & Kenney (2007)</td><td>In the RIS of Beijing, universities have close relationships with industry through joint projects, professional consulting, training and THU built a science park as an incubator to develop start-ups.</td></tr>
</table>

Jiao, Zhou, Gao and Liu (2016) indicate that a university in China, in a core region emerging-economy context, supports regional innovation by producing ‘deliverable innovation’ for commercialisation. From the case of the RIS in Shanghai, local universities have been increasingly involved in research collaboration with firms in the biotech and telecommunications industry (Asheim & Vang, 2011). Similarly, CMU offered academic services to firms in Northern Thailand to produce innovations, from which firms can also commercialise their new products via collaborative projects with CMU researchers in the market. While the services offered can be seen as similar, the sectors are fundamentally different as the peripheral context of Northern Thailand that is focused on the agri-food industry. In the RIS of Beijing, universities also have close relationships with industry through joint projects, professional consulting, training and THU built a science park as an incubator to develop start-ups (Chen & Kenney, 2007). Similarly, CMU cooperated with STeP to serve firms in Northern Thailand through STeP programme services, including undertaking R&D activities, offering consulting services, and providing training and laboratory testing. Thus, the roles of CMU in the specific peripheral region developing-economy context of the NT-RIS support those from literature in a core region developing-economy context.

6.4.2 Summary and identification of contributions

The critical literature review identified a gap in the literature on RISs, specifically in terms of the peripheral region developing-economy context. Because this study was conducted in a peripheral region of Thailand's developing economy and many of the contributions support the existing literature conducted in slightly different contexts (either in a peripheral region developed economy or a core region developing economy), the contribution largely supports existing findings despite its different context.

In the literature, two groups of prior research exist that have applied an innovation system approach to identify characteristics and explore RISs. The first group of 'comparative studies between various regions' reveals differences in systemic nature, while the second group of studies illustrate the 'details of individual RIS' to identify factors for sustaining the system, as well as the dynamics and interactions between actors within an individual region (Doloreux & Parto, 2005). As this thesis has explored the NT-RIS individually and then compared it with other RISs in the literature, it covers both areas of research existing in the literature, contributing to both streams of literature on RISs.

In addition, however, this thesis also identifies the unique characteristics of the peripheral region developing-economy RIS in Northern Thailand. Specifically:

1) The university (CMU) has a particularly important role in the system development of the RIS in Northern Thailand, having more developed input in terms of innovation activities through its relationship with the science park.

2) The science park (STeP) acts as one of the key actors in the NT-RIS, highlighting a greater capacity-building role than exists in previous literature conducted in other contexts.
3) Owing to the specific context in which the science park (STeP) operates, the interactive innovation processes highlight various differences with the existing literature, including a greater role in product development.
4) The university (CMU) and science park (STeP) provide IP management and training to a greater extent to that emphasised in the peripheral RISs of developed countries.
5) While the interactions within the RIS–university–science park nexus in NT-RIS have evolved to be similar to the interactions in RISs of core regions of other developing economies, the RIS in Northern Thailand focuses on the 'core area' (Chiang Mai) of a peripheral region and a clustered sector (agri-food), which is different from that of other studies.
6) The RIS in Northern Thailand is in the developing phase, with the interactions and coherence among actors overall being more limited and more developmental than in the contexts focused on in previous literature.

6.5 Conclusions

There have been a limited number of studies illustrating how the role of the science park, particularly through interactions with the university, could help develop RISs, particularly in the peripheral region developing-economy context. This research, therefore, contributes to closing this gap by demonstrating the interactive innovation processes within the RIS–university–science park nexus in Northern Thailand. By comparing the specific NT-RIS with the existing literature, which is predominantly focused on RISs in peripheral region developed-economy and core region developing-economy contexts, the study contributes to the literature, providing evidence of the similarities and differences to other contexts. As the specific NT-RIS is still in a developing phase, it also needs to be further developed. The next chapter concludes this thesis, identifying the key findings and implications, summarising the contributions of this thesis, identifying the limitations and outlining areas for further research.

Chapter 7: Conclusion

7.1 Introduction

This thesis has taken CMU, a prestigious university in Northern Thailand that collaborated with a science park (STeP) to offer its resources to on-park firms, as a case study through which to investigate the roles of the university and its interactions within the RIS–university–science park nexus of a peripheral region in a developing-economy context. The interactions between CMU, STeP, on-park firms, spin-off firms and other actors in the region are also believed to identify promising RIS-enhancing activities for the longer term.

By way of conclusion, this chapter begins with an overview of the key findings and contributions. The next section highlights policy implications in relation to the findings of this thesis. Then, the limitations of this thesis and suggestions for future research are discussed. Finally, the thesis ends with concluding remarks.

7.2 Key findings and contributions

Table 7.1, below, summarises the research questions, key literature and consequent contributions to knowledge and practice of this thesis.

TABLE 7.1 RESEARCH QUESTIONS, KEY LITERATURE AND THE CONTRIBUTIONS OF THIS THESIS

Research questions	Key literature	Summary of contributions to knowledge and practice
RQ1: What are the specific roles of the university and relationships between the RIS, university and science park actors? **RQ2:** What are the specific roles of the university and relationships between the RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?	Some studies have linked together the literature on RISs and science parks (e.g., Hommen et al., 2006; Jonsson, 2002; Zhang, 2015; Zhu & Tann, 2005). There has been no general theory on science parks due to the origins of the parks being different depending on several factors and the context of each country (Phan et al., 2005). Some studies have focused on the roles of universities and relationships with science parks and other RIS actors (e.g., Hommen et al., 2006; Zhu & Tann, 2007).	The first specific contribution to knowledge is the development of a two-dimensional matrix from a systematic literature review, applied to identify the roles of the university in its interrelationships between RIS–university, RIS–university–science park and university–science park actors in a peripheral-region-developing economy context. This also contributes to practice; the matrix is capable of being applied to other regions, allowing them to compare their activities against the matrix in order to identify areas where they may need to further develop policy. Applying the matrix, identifying the unique characteristics of the roles of the university in a peripheral region developing-economy context of the RIS in Northern Thailand identifies that, in addition to the relative weakness of many of the cells in comparison with the literature, specific roles emphasised in this under-researched context are building regional networks, research collaboration, knowledge intermediaries, and promoting the commercialisation of research results. The results highlight that the university is relatively new to the role of the entrepreneurial university and that the NT-RIS is largely still nascent, with firms having capacity issues which the university is having to address simultaneously through supporting innovating firms with capacity-building activities.

RQ3a: What are the roles of the university in its relationships between the RIS, university and science park actors in innovation projects conducted with on-park firms? **RQ3b:** How does the university contribute to the innovation activities of on-park firms in the context of a peripheral developing economy? **RQ4:** How do the university and science park contribute to the development of a peripheral RIS in a developing economy?	In chapter three, Cooke, Roper and Wylie (2003), Doloreux (2003), Doloreux and Dionne (2008), Doloreux, Isaksen, Aslesen and Melançon (2009), and Tödtling and Sedlacek (1997) provided basic insights into interactive innovation processes among actors in peripheral RISs. Describing the characteristics of peripheral RISs (e.g., Asheim & Isaksen, 1997; Asheim, Moodysson, & Tödtling, 2011; Doloreux, 2003; Doloreux & Dionne, 2008; Isaksen, 2001; Tödtling & Trippl, 2005). Illustrating the supportive element in RISs (providing specialist training and education to actors as well as offering specialist programmes) (e.g., Asheim & Isaksen, 1997; Isaksen, 2001; Tödtling & Sedlacek, 1997). Showing the roles of the university in an RIS of a developing-economy country (e.g., Asheim & Vang, 2011; Chen & Kenney, 2007; Jiao, Zhou, Gao, & Liu, 2016).	In identifying the roles of the university in the actual innovation process, the research provides a second clear contribution to knowledge in identifying in detail the specific innovation processes at work. The findings indicate that amongst the 12 cases studied, the university in the peripheral region developing-economy NT-RIS supports four specific processes. These focus on research relationships, product development, knowledge transfer and innovation impact. The findings also identified three specific university-provided innovation success-driving factors which were particularly associated with more successful outcomes of the innovation process as perceived by the firms themselves, helping to answer how the university contributes to on-park firms in the context of a peripheral developing economy. These three factors are related to pre-STeP programme training, CMU researchers acting as knowledge intermediaries in organising external experts to participate in research collaborations leading to further sharing of knowledge and ideas, and provision of IP training to firms. Using the research to identify the roles of the university in developing the RIS itself in this peripheral region developing-economy context, also identifies that the university has a more developed input (than identified in previous literature) in terms of innovation activities through its relationship with the science park, including a greater and more direct role in product development, providing IP management and training to a greater extent to that emphasised in previous literature focused on peripheral RISs of developed countries. In addition, while unsurprisingly, the interactions in the NT-RIS have evolved to be similar to the interactions in RISs of core regions of other developing economies, and the RIS in Northern Thailand focuses on the 'core area' of the peripheral region (Chiang Mai, it is focused on a clustered sector (agri-food), which is different to that of other studies. Additionally, because the RIS in Northern Thailand is in the developing phase, the interactions and coherence among actors overall are more limited and developmental than in the contexts focused on in previous literature. This also contributes to practice by demonstrating a number of policy areas (for universities, science park and government) to promote the functioning of the NIS and RIS in Thailand.

7.2.1 Contributions to knowledge

This thesis has two key contributes to knowledge (see Table 7.1). The first contribution of this thesis is through the building of a two-dimensional matrix identifying the roles of the university and its relationships to RIS actors, the roles of the university and its relationships to the science park as well as the roles of the university in simultaneous relationships with both RIS actors and the science park. By conducting a systematic literature review, it revealed that few studies (e.g., Hommen et al., 2006; Jonsson, 2002; Zhang, 2015; Zhu & Tann, 2005) have linked the literature on RISs and science parks, leading to the necessity to examine the role of the university in the science park within the context of a specific RIS. The two-dimensional matrix was built from empirical evidence found in the existing literature to fill this gap and bridge both literature streams. Importantly, because the matrix can be applied to a range of national and regional contexts in order to analyse the roles of universities and their relationships with science parks and other actors, it was then adopted as a conceptual framework for use in this thesis. Thus, it makes a general contribution to knowledge.

By reviewing the literature on science parks, a gap was found highlighting that no general theory on science parks exists due to the origins of the parks being different depending on several factors and the context of each country (Phan et al., 2005). From the systematic literature review, it was also revealed that the university is found to be a crucial component in both RISs and science parks, but only a limited number of studies (e.g., Hommen et al., 2006; Zhu & Tann, 2007) have focused on the roles of universities and relationships with the science park and other RIS actors. Consequently, research needs to look at these issues in specific national and regional contexts. This thesis, finally, fills this gap by examining the roles and relationships of a science park (STeP) in the specific peripheral region developing-economy RIS context of Northern Thailand.

By applying a two-dimensional matrix (the conceptual framework) and comparing each role of CMU in the conceptual framework with those from the existing literature, the result shows that, in many areas, CMU’s activities appear weaker than identified in the literature.

In addition, however, CMU has four relatively emphasised roles, which, while not stronger than those identified in the literature, are stronger than the other cells in the matrix. These are building regional networks, research collaboration, knowledge intermediaries, and promoting the commercialisation of research results. Interestingly, the role of CMU as a knowledge intermediary is considered to be the most specifically emphasised role because most of the characteristics of this role are similar to evidence identified in the literature, and CMU researchers have the apparent processes necessary to transfer knowledge to firms in their collaborative projects.

In addition, this thesis identifies the ‘unique characteristics’ of CMU’s roles in this context, namely: providing information to RIS actors via a database; offering general business training, seminars and IP training to all actors in the NT-RIS; setting up meetings as the channel of communication between firms, researchers and other participants in their projects; providing use of specific facilities in terms of the café, plant and factory, library, intranet and online library as well as computers; setting up an annual conference and excellence centres and connecting with other universities in Northern Thailand; transferring knowledge to firms by searching for new knowledge, directly undertaking R&D activities and transferring knowledge to firms; and offering IP services (consulting and training) to firms. This highlighted the unique characteristics of CMU’s role in commercialisation and promoting technological change. These results also identify that, in this peripheral region developing-economy context, the university is relatively new to the role of the entrepreneurial university and the RIS (of Northern Thailand) is largely still nascent, with firms having capacity issues which the university is having to address simultaneously through supporting innovating firms with capacity-building activities.

The second main contribution to knowledge is identified by reviewing the specific research context. Cooke, Roper and Wylie (2003), Doloreux (2003), Doloreux and Dionne (2008), Doloreux, Isaksen, Aslesen, and Melançon (2009), and Tödtling and Sedlacek (1997) provided only basic insights into the interactive innovation processes among actors in peripheral RISs in developed-economy contexts. These studies did not specifically examine the processes occurring. Identifying in detail the roles of the university in the actual innovation process, the research provides a second clear contribution to knowledge. It does this in two ways.

First, this thesis uncovers four distinct interactive innovation processes within the RIS–university–science park nexus. These are the research relationship process (emphasising cell 5), the product development process (emphasising cell 8), the knowledge transfer process (emphasising cell 6) and the impact process (emphasising cell 9). To illustrate the contribution to knowledge in terms of specific interactive innovation processes among actors in a peripheral RIS of a developing-economy context, the interactive innovation processes among actors in a specific NT-RIS were compared with those appearing in literature (including Cooke, Roper, & Wylie, 2003; Doloreux, 2003; Doloreux & Dionne, 2008; Doloreux, Isaksen, Aslesen, & Melançon, 2009; Tödtling & Sedlacek, 1997). The result showed that, in the interactive innovation processes, CMU helped firms to solve business problems, encouraged the commercialisation of research results, supported technology transfer, and developed incremental innovations and product development; in addition, some CMU researchers participated in the collaborative projects with firms. This supports evidence in the literature. Moreover, the findings indicated that CMU cooperated with the science park (STeP) to allow researchers to participate in STeP programmes, including the undertaking of linking roles. Given that the firms in this specific NT-RIS did not collaborate with other firms, universities or research institutions located outside the region to undertake these linking roles, there is a clear difference from the existing evidence in the literature. The findings from 12 case studies of more successful and less successful projects that CMU researchers undertook with firms from the STeP programme also identified a contribution in terms of identifying success-driving factors, in the context of a peripheral developing economy. The three factors were: the pre-STeP programme training, CMU researchers acting as knowledge intermediaries in organising external experts to participate in research collaborations leading to further sharing of knowledge and ideas, and provision of IP training to firms.

Second, this thesis provides the evidence of how the university and science park contribute to the development of a peripheral RIS in a developing economy, through these processes.

The findings of this thesis show that the innovation activities in a specific NT-RIS have been more developed than other peripheral RISs due to CMU researchers and firms creating new products. This is different from the evidence in the literature. However, limited networking among actors and organisational thinness were also identified. This supports the evidence of Asheim and Isaksen (1997), Asheim, Moodysson and Tödtling (2011), Doloreux (2003), Doloreux and Dionne (2008), Isaksen (2001), and Tödtling and Trippl (2005), that highlights that peripheral RISs are characterised by organisational thinness and limited networks among actors. This thesis also showed that CMU acted as a supportive element in the RIS by providing specialist training and education to actors as well as offering specialist programmes to encourage technology transfer. While this supports evidence of Asheim and Isaksen (1997), Isaksen (2001), and Tödtling and Sedlacek (1997) that highlighted 'forums' and 'specialist organisation/programmes' are supportive elements in other peripheral RISs, the context in this thesis is different in that it is through CMU collaborating with STeP (to allow CMU to provide these services and researchers to undertake research contracts and R&D activities with firms) that the science park is specifically involved in developing the peripheral RIS.

CMU encourages regional innovation by helping firms to produce innovation for commercialisation; it is also increasingly involved in research collaboration as well as cooperating with STeP to offer various services to firms. This supports the evidence of Asheim and Vang (2011), Chen and Kenney (2007), and Jiao, Zhou, Gao, and Liu (2016), which illustrated the roles of universities in RISs in a developing-economy country. However, while the evidence of this thesis suggests that STeP's roles and interactions within the RIS–university–science park nexus in a specific NT-RIS have evolved to be similar to those of RISs in core regions of developing economies, the focus has been on a clustered sector (agri-food) which is different from those in other studies. This also indicates how STeP is helping to build a specific RIS in Northern Thailand.

7.2.2 Contributions to practice

The research also makes contributions to practice, both in the specific Thai context but also more generally. The first contribution to practice is in terms of the two-dimensional matrix illustrating the roles of the university and relationships between the RIS–university, RIS–university–science park, and university–science park actors. The matrix allows other regions to compare their activities against the matrix to identify areas that they may need to develop further.

In this thesis, the matrix was used to analyse the roles of CMU, the linkages between actors and the factors affecting the roles of CMU in a specific NT-RIS. The findings of this thesis, therefore, also make a contribution to practice in the Thai context. Evidence presented in this thesis illustrates that government agencies have attempted to strengthen innovation systems (the NIS and RISs) in Thailand by launching supportive policy and plans as well as establishing science parks in the country's regions. However, only the National Science, Technology and Innovation Policy and Plan (2012–2021) is considered to support innovation systems in Thailand. This thesis contributes to practice by demonstrating a limited number of policies promoting the functioning of the NIS and RIS in Thailand. The government and authorities, therefore, should develop supportive policies to enhance the Thai innovation systems.

7.3 Implications for policy practice and policy formulation

By analysing the roles of CMU based on the matrix, this thesis also identifies a number of implications for policy practice and policy formulation. Looking at policy practice, the first implication for policy practice, in terms of university practice specifically, is that the thesis shows the four relatively strongest roles of CMU: building regional networks, research collaboration, knowledge intermediaries, and promoting the commercialisation of research results. CMU should, therefore, enhance its capabilities, especially on its less specific roles, including providing information, providing communication channels, providing infrastructure, economic development/wealth creation and developing commercialisation through IP management as well as promoting technological change.

A second, again university policy-related, implication relates to the identified process activities that help build the RIS, including the research relationship process (emphasising cell 5), the product development process (emphasising cell 8), the knowledge transfer process (emphasising cell 6) and the impact process (emphasising cell 9). Comparing these processes with the interactive innovation processes of the 12 case studies, the results also showed the 'success-driving factors of more successful projects'. This highlights that CMU could improve roles, which are not currently considered to be success-driving factors, but which may also be important, such as exchanging information, providing infrastructure and setting up communication channels among actors.

Comparing the operational processes of the STeP programme with those of the NT programme, this thesis identifies a third policy-related implication, as it indicates that the operational processes of these two programmes are similar, particularly in terms of selecting firms to participate in programmes as well as providing funding and all-round support to firms. The STeP programme did not, however, 'actively follow up firms and projects', suggesting authorities should add this service into the programme. Additionally, because the findings of this thesis showed that some spin-off firms had not commercialised their new products due to the products not having been sufficiently developed by the end of the STeP programme, the government should consider extending the duration of the STeP programme for some projects. This also has policy implications more generally.

According to Chaminade, Intarakumnerd and Sapprasert (2012), and Intarakumnerd and Chaminade (2007), the practice of the Thai innovation system followed ‘old innovation paradigms’, and the ‘linear model of innovation’ has influenced science and technology policy formation in Thailand for many decades. Supported by the findings of this thesis, CMU researchers served firms in their projects by undertaking R&D activities and transferring knowledge to firms, which also highlights a linear model of innovation. Currently, this suggests a lack of focus on the importance of regional and international links. Therefore, as a fourth policy practice implication to develop innovation systems in Thailand, the authorities should become more aware of the complex, multidimensional nature of innovation based on the interactive model.

Demonstrated in the research context chapter (chapter three), additional policy formulation implications can also be drawn from the experience of the Thai NIS. Specifically, to successfully develop and sustain an RIS in Thailand, the policy formulation recommendations in relation to the findings of this thesis are provided as follows.

First, the government should design policies to specifically match with the regional context. As grants are necessary to encourage firms to participate in collaborative projects with university researchers, the government and authorities should consider offering matching grants. According to Andersson and Karlsson (2006), Isaksen (2001), and Tödtling and Trippl (2005), policy measures and various approaches, such as linking regional firms to external clusters and national knowledge providers as well as attracting innovative firms to the region, are important for promoting RISs in peripheral regions. However, there have been a limited number of policy measures to support the links with external clusters and attract innovative firms to this region of Thailand. This emphasises that further development of the NT-RIS should consider these issues.

Secondly, most universities in the regions of Thailand have been functioning based on traditional roles, including teaching and generating knowledge through research.

Therefore, authorities should design policy by adopting the entrepreneurial university concept where universities can become increasingly involved in entrepreneurial activities. Additionally, they must set up a policy to stimulate cooperation between universities and other actors. The policy should initiate from promoting informal relationships between actors and then transforming these into more formal relationships. In addition, universities must enhance their capabilities to meet the needs of industry. Also, the government should provide sufficient budgets, allocated to universities with a focus on industrially needed research projects.

Thirdly, STeP was established as an intermediary organisation. It connected firms, the university and other actors in a specific NT-RIS. Nevertheless, limited cooperation among RIS-university-science park actors has been observed from the findings of this thesis. Authorities, therefore, should develop policies to enhance the interactions between actors by promoting social relationships and information exchange through activities, such as seminars and conferences specifically to the sectors of firms, as well as offering incentives to attract firms participating in STeP programmes.

Lastly, the findings of this thesis showed that the NT-RIS has been developing based on a 'top-down' approach. According to Njøs & Fosse (2019), the evolution of RIS has been come from the 'dialectical dynamics between bottom-up and top-down process'. The balancing between bottom-up and top-down approach is, therefore, crucial and the Thai government should consider on this issue to further develop the NT-RIS.

7.4 Limitations of this thesis and suggestions for future research

It is crucial to be aware that the findings of this thesis are subject to some limitations. First, this thesis aimed to investigate the roles of CMU and the relationships within the RIS–university–science park nexus in a specific NT-RIS during its developing phase. Given the RIS in Northern Thailand's limited existence (in numbers of years) and the small number of firms in the science park (STeP), findings from this thesis may be time-specific. The findings suggest that the RIS and science park need several years to develop well-established processes, and therefore further research in this specific geographical context in the future is still required. Secondly, this thesis explored the interactive innovation processes in projects of firms and researchers that affected the commercialisation of research results in a specific region of Thailand, in a specific peripheral-region-developing economy context. Given that the research suggests that this context is important then limitations also exist in terms of generalisation to other, different, contexts. However, within the peripheral-region-developing economy context it is believed the results have generalisability, the techniques used allowing this belief to be tested in future research.

This leads to the following suggestions for future research. Firstly, the two-dimensional matrix developed in this thesis could be used to explore the roles of universities and the relationships between actors in innovation systems in both similar and different contexts. This future research also needs to identify the effective and defective determinants for developing the roles of universities and interactions among actors in these differing contexts.

Secondly, future research which explores in more detail the obstacles for collaborating in the specific NT-RIS would lead to a greater understanding of the necessary conditions for stimulating interactive innovation processes among actors in this specific context.

Thirdly, it is evidenced in this thesis that the linkages between actors in the specific NT-RIS are weak. In this respect, future research could focus on the cooperative networks among actors, with a particular emphasis on possible frameworks that could facilitate better cooperation.

Fourthly, future research should focus on how firms in Northern Thailand interact with other external sources of knowledge, such as research institutions, customers, suppliers, and so on. As a result, this could help understand how firms interact with their external links to acquire new knowledge.

As this thesis explored only a specific NT-RIS, future research should investigate the RISs of the other regions in Thailand. This would be beneficial in uncovering how the roles of universities and relationships between actors in Thai RISs could be developed to enhance the functioning of the Thai NIS more broadly.

7.5 Concluding remarks

Despite these limitations, this thesis has made important contributions to knowledge and practice in the context of the RIS–university–science park nexus, revealing a complex set of activities taking place in the peripheral RIS of the developing-economy context of Thailand. Specifically, the roles of the university and the relationships within the RIS–university–science park nexus have been identified.

The evidence and findings from this thesis could help both authorities and policymakers who are responsible for developing the Thai RISs to better understand the recent situation of a peripheral RIS in Thailand, as well as to more fully understand the roles of the university in its relationships with actors in a specific region of the country. Additionally, the policy implications provided in this thesis could guide authorities and policymakers to develop more supportive policies for promoting RISs in Thailand.

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Appendices

Appendix 1: Interview Guides for Phase 1 and 2

Interview Questions for Phase 1

- Question-**Please tell me about the organisation and its interactions and with other stakeholders in the region. (5 minutes)** The question was inspired by Gunasekara (2006); Lew, Khan, & Cozzio (2016); Ratinho & Henriques (2010); Vedovello (1997).

1) Interview Guides for university–science park executives

The roles of university and the interactions between university, spin-off firms and the other RIS actors: The questions came from a two-dimensional matrix.

Research Question 2	**What are the specific roles of the university and relationships between RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?**
	RIS actors + University or Knowledge co-creation **(Basic Research)**
Resource Sharing	**(Cell 1)** **Provision of information (5 minutes)** **Question:** What information / other resources does the university provide for the RIS? (The question was inspired by the matrix.)
Brokerage Role	**(Cell 4)** **Building regional networking (5 minutes)** **Question:** Does the university help to build regional networks and if so how? (The question was inspired by the matrix.)
Exploitation and Commercialisation	**(Cell 7)** **Economic development and wealth creation (5 minutes)** **Question:** Does CMU have any policies or strategies to promote the regional economic development and wealth creation of the region and if so what are these? (The question was inspired by the matrix.)

-The roles of university and the interactions between university, science park, on-park firms and spin-off firms

Research Question 2	**What are the specific roles of the university and relationships between RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?**
	RIS actors + University + SP or Conduit **(Product Development)**
Resource Sharing	**(Cell 2)** **Providing the channels of communication (5 minutes)** **Question:** Does CMU provide channels of communication between science park, on- park firms and spin-off firms and if so how? **The questions were inspired by Vedovello (1997) and Lew et al. (2016).**
Brokerage Role	**(Cell 5)** **Research collaboration** (R&D activities between actors) **(5 minutes)** **Question:** Does CMU facilitate research collaboration between the science park, on-park firms and spin-off firms and if yes, how? (The question was inspired by the matrix.)
Exploitation and Commercialisation	**(Cell 8)** - **Development of Commercialisation** (e.g., licensing activities, patents) - **Promoting technological change (5 minutes)** **Question:** Does CMU promote collaboration to exploit and commercialise research between the science park, on-park firms and spin-off firms and if yes, how? (The question was inspired by the matrix.)

-The roles of university and the interactions between university, science park and on-park firms

Research Question 2	**What are the specific roles of the university and relationships between RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?**
	University + SP or Interorganisational relations **(Applied Research)**
Resource Sharing	**(Cell 3)** **Provision of infrastructure (5 minutes)** **Question:** Does CMU provide infrastructure to science park and on-park firms and if so what kinds? (The question was inspired by the matrix.)
Brokerage Role	**(Cell 6)** **Knowledge intermediaries (5 minutes)** **Question:** Does the CMU/researcher act as knowledge intermediary during the interactions with science park and on- park firms and if yes, how? (The question was inspired by the matrix.)
Exploitation and Commercialisation	**(Cell 9)** - **Start-ups creation** (incubator) - **Promoting the commercialisation of research results (5 minutes)** **Question:** How successful do you think the start-ups creation (incubator programme) has been in terms of exploitation and commercialisation and why? (The question was inspired by the matrix.)

2) Interview Guides for Policy and Plan Analysts of SPA

The roles of university and the interactions between university, spin-off firms and the other RIS actors: The questions came from a two-dimensional matrix.

Research Question 2	**What are the specific roles of the university and relationships between RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?**
	RIS actors + University or Knowledge co-creation **(Basic Research)**
Resource Sharing	**(Cell 1)** **Provision of information (5 minutes)** **Question:** Does CMU and / or its researchers provide information or other resources to spin-off firms or other RIS actors and if yes, what and how? (The question was inspired by the matrix.)
Brokerage Role	**(Cell 4)** **Building regional networking (5 minutes)** **Question:** Does the university help to build regional networks and if so how? (The question was inspired by the matrix.)
Exploitation and Commercialisation	**(Cell 7)** **Economic development and wealth creation (5 minutes)** **Question:** Do you think CMU has policies and / or strategies to promote the regional economic development and wealth creation of firms in the region, and if so, what do you think about these? (Lew, Khan, & Cozzio, 2016)

-The roles of university and the interactions between university, science park, on-park firms and spin-off firms

Research Question 2	What are the specific roles of the university and relationships between RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?
	RIS actors + University + SP **or** Conduit **(Product Development)**
Resource Sharing	**(Cell 2)** **Providing the channels of communication (5 minutes)** **Question:** Does CMU provide channels of communication between science park, on- park firms and spin-off firms and if so what are these and how effective do you think these are? (The question was inspired by the matrix.)
Brokerage Role	**(Cell 5)** **Research collaboration** (R&D activities between actors) **(5 minutes)** **Question:** Does CMU broker research collaboration between science park, on-park firms and spin-off firms and if so, how? (e.g., joint research (Motohashi, 2013), R&D activities , others))
Exploitation and Commercialisation	**(Cell 8)** - **Development of Commercialisation** (e.g., licensing activities, patents) **(5 minutes)** **Question:** Do you think CMU promotes collaboration to exploit and commercialise research between the science park, on-park firms and spin-off firms and if yes, how? (The question was inspired by the matrix.)

3) **Interview Guides for entrepreneurs of on-park firms**

-The roles of university and the interactions between university, science park, on-park firms and spin-off firms

Research Question 2	**What are the specific roles of the university and relationships between RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?**
	RIS actors + University + SP or Conduit **(Product Development)**
Resource Sharing	**(Cell 2)** **Providing the channels of communication (5 minutes)** **Question:** Does CMU provide channels of communication between you and the science park, the other on- park firms and spin-off firms and if so, what are these channels and how do they work? **The questions were inspired by Vedovello (1997) and Lew et al. (2016).**
Brokerage Role	**(Cell 5)** **Research collaboration** (R&D activities between actors) **(5 minutes)** **Question:** How does CMU brokering research collaboration between science park and on-park firms and spin-off firms affect you? (The question was inspired by the matrix.)
Exploitation and Commercialisation	**(Cell 8)** - **Development of Commercialisation** (e.g., licensing activities, patents) - **Promoting technological change (5 minutes)** **Question:** Does CMU and science park help you to launch your new products and if so how and how beneficial is this? (Löfsten & Lindelöf, 2003)

-The roles of university and the interactions between university, science park and on-park firms

Research Question 2	What are the specific roles of the university and relationships between RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?
	University + SP or Interorganisational relations (Applied Research)
Resource Sharing	**(Cell 3)** **Provision of infrastructure (5 minutes)** **Question:** Does CMU provide infrastructure to you and If yes, what kinds of infrastructure do you or the researcher use to serve you, and what are the benefits or drawbacks of using the infrastructure? (The question was inspired by the matrix.)
Brokerage Role	**(Cell 6)** **Knowledge intermediaries (5 minutes)** **Question:** Does CMU act as an intermediary in brokering you expertise or knowledge to solve problems in your business and If yes, how does this process work, and how beneficial is this for you? (The question was inspired by the matrix.)
Exploitation and Commercialisation	**(Cell 9)** - **Start-ups creation** (incubator) - **Promoting the commercialisation of research results (5 minutes)** **Question:** How successful do you think the start-ups creation (incubator programme) has been for your firm in terms of exploitation and commercialisation and why? (The question was inspired by the matrix.)

4) Interview Guides for entrepreneurs of spin-off firms

-The roles of university and the interactions between university and spin-off firms: The questions came from a two-dimensional matrix.

Research Question 2	What are the specific roles of the university and relationships between RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?
	RIS actors + University or Knowledge co-creation **(Basic Research)**
Resource Sharing	**(Cell 1)** **Provision of information (5 minutes)** **Question:** Does CMU / researcher still provide any information resources to you, and if so, what and how? (The question was inspired by the matrix.)
Brokerage Role	**(Cell 4)** **Building regional networking (5 minutes)** **Question:** Has the university helped you to access regional networks and if so how? (The question was inspired by the matrix.)
Exploitation and Commercialisation	**(Cell 7)** **Economic development and wealth creation (5 minutes)** **Question:** Did your business benefit in terms of greater exploitation and commercialisation after finishing the programme and if so how? (The question was inspired by the matrix.)

-The roles of university and the interactions between university, science park, on-park firms and spin-off firms

Research Question 2	**What are the specific roles of the university and relationships between RIS, university and science park actors in the case of a peripheral region developing-economy case (Northern Thailand)?**
	RIS actors + University + SP **or** Conduit **(Product Development)**
Resource Sharing	**(Cell 2)** **Providing the channels of communication (5 minutes)** **Question:** Does CMU still provide channels of communication between you and the science park and on-park firms and other spin-off firms and if so what are these and how do they operate? **The questions were inspired by Vedovello (1997) and Lew et al. (2016).**
Brokerage Role	**(Cell 5)** **Research collaboration** (R&D activities between actors) **(5 minutes)** **Question:** How did CMU brokering research collaboration between the science park, on-park firms and spin-off firms affect you? (The question was inspired by the matrix.)
Exploitation and Commercialisation	**(Cell 8)** - **Development of Commercialisation** (e.g., licensing activities, patents) - **Promoting technological change (5 minutes)** **Question:** Did CMU and the science park help you to launch your new products and if so how and how beneficial is this? (Löfsten & Lindelöf, 2003)

Interview Questions for Phase 2

Interview Guides for Researchers

Research Question 3a: What are the roles of the university in its relationships between RIS, university and science park actors in innovation projects conducted with on-park firms? **Research Question 3b: How does the university contribute to the innovation activities of on-park firms in the context of a peripheral developing economy?**	
	RIS actors + University or Knowledge co-creation **(Basic Research)**
Resource Sharing	**(Cell 1)** **Provision of information (5 minutes)** What information/knowledge did you share with regards to the background of the project with the entrepreneur and / or other RIS actors? (The question was inspired by the matrix.)
Brokerage Role	**(Cell 4)** **Building regional networking (5 minutes)** What researchers from other institutions or parts of the RIS, if any, participate in the project and how?? (The question was inspired by the matrix.)
Exploitation and Commercialisation	**(Cell 7)** **Economic development and wealth creation (5 minutes)** In your perception how was the regional economy and wealth creation of firms in the region developed through the project? (The question was inspired by the matrix.)

Research Question 3a: What are the roles of the university in its relationships between RIS, university and science park actors in innovation projects conducted with on-park firms? **Research Question 3b: How does the university contribute to the innovation activities of on-park firms in the context of a peripheral developing economy?**	
	RIS actors + University + SP or Conduit **(Product Development)**
Resource Sharing	**(Cell 2)** **Providing the channels of communication (5 minutes)** For the project, how did you provide channels of communication between the CMU, science park, and the firm? The questions were inspired by Lew, Khan, & Cozzio (2016); Vedovello (1997)**.**
Brokerage Role	**(Cell 5)** **Research collaboration** (R&D activities between actors) **(5 minutes)** Please tell me what the research project was about and your role in the project. (The question was inspired by the matrix.)
Exploitation and Commercialisation	**(Cell 8)** - **Development of Commercialisation** (e.g., licensing activities, patents) - **Promoting technological change (5 minutes)** What role did you play in the exploitation and commercialisation of research results/the result from the project (e.g., in terms of licensing activities, patents, etc.)? (The question was inspired by the matrix.) Do you promote technological change through training? (The questions were inspired by Dierdonck, Debackere, & Rappa (1991)) or through the meeting, conference, R&D and formal contact? (The question was inspired by Jonsson (2002).)

Research Question 3a: **What are the roles of the university in its relationships between RIS, university and science park actors in innovation projects conducted with on-park firms?** **Research Question 3b:** **How does the university contribute to the innovation activities of on-park firms in the context of a peripheral developing economy?**	
	University + SP or Interorganisational relations **(Applied Research)**
Resource Sharing	**(Cell 3)** **Provision of infrastructure (5 minutes)** What CMU infrastructure did you use in the project with the firm and how is this used? (The question was inspired by the matrix.)
Brokerage Role	**(Cell 6)** **Knowledge intermediaries (5 minutes)** What knowledge do you search for and how is this transferred into the project? (e.g., by searching the academic papers, consulting with the other expertise) (The question was inspired by the matrix.)
Exploitation and Commercialisation	**(Cell 9)** - **Start-ups creation** (incubator) - **Promoting the commercialisation of research results (5 minutes)** In your perception did you think the project was successful or not, in what ways, and why? (The question was inspired by the matrix.)

Interview Guides for entrepreneurs of on-park firms (who have already completed at least one project with CMU) and spin-off firms who have moved off park since the end of the project.

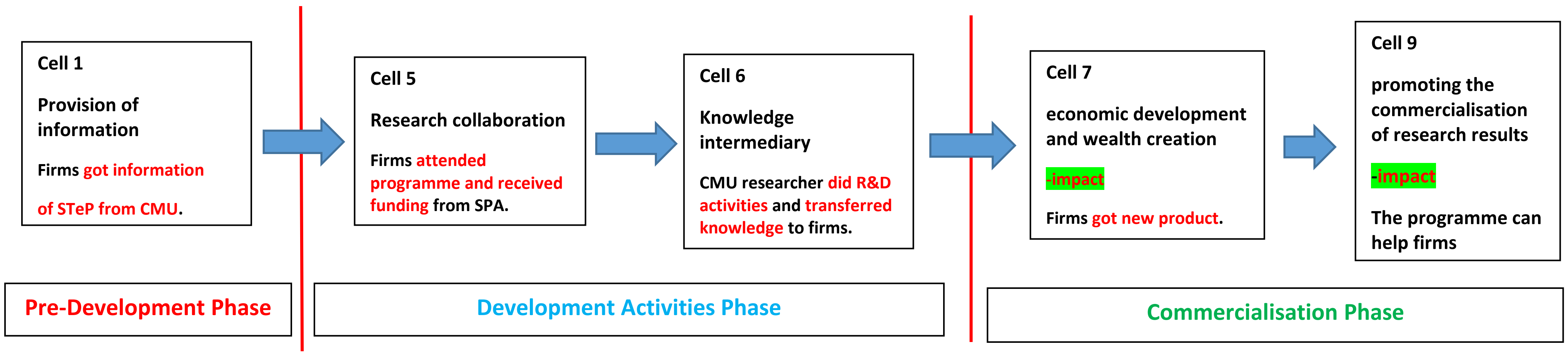
Research Question 3a: What are the roles of the university in its relationships between RIS, university and science park actors in innovation projects conducted with on-park firms? **Research Question 3b: How does the university contribute to the innovation activities of on-park firms in the context of a peripheral developing economy?**	
	RIS actors + University or Knowledge co-creation **(Basic Research)**
Resource Sharing	**(Cell 1)** **Provision of information (5 minutes)** What information/knowledge of relevance to the project did you receive from CMU researchers? And how useful was this (The question was inspired by the matrix.)
Brokerage Role	**(Cell 4)** **Building regional networking (5minutes)** Apart from the university, were there other organisation involved in the project (other RIS actors e.g., funding agency), did CMU play any part in facilitating this and if so, how? The questions were inspired by Lew, Khan, & Cozzio (2016); Vedovello (1997).
Exploitation and Commercialisation	**(Cell 7)** **Economic development and wealth creation (5minutes)** In your perception how was the regional economy and wealth creation of your firm (and others in the region) developed through the project? (The question was inspired by the matrix.)

Research Question 3a: What are the roles of the university in its relationships between RIS, university and science park actors in innovation projects conducted with on-park firms? **Research Question 3b:** How does the university contribute to the innovation activities of on-park firms in the context of a peripheral developing economy?	
	RIS actors + University + SP **or** Conduit **(Product Development)**
Resource Sharing	**(Cell 2)** **Providing the channels of communication (5 Minutes)** For the project, with whom in the university/science park did you work, what kinds of links did you have? (formal, informal and human resources interaction) and what were the channels of communication between CMU, the science park, and your firm? The questions were inspired by Lew, Khan, & Cozzio (2016); Vedovello (1997).
Brokerage Role	**(Cell 5)** **Research collaboration** (R&D activities between actors) **(5 Minutes)** Please tell me what the research project was about, how it was facilitated and supported by CMU and your role in the project. (The question was inspired by the matrix.)
Exploitation and Commercialisation	**(Cell 8)** - **Development of Commercialisation** (e.g., licensing activities, patents) - **Promoting technological change (5 minutes)** What roles did CMU and you play in the exploitation and commercialisation of research results/the result from the project? (The question was inspired by the matrix.)

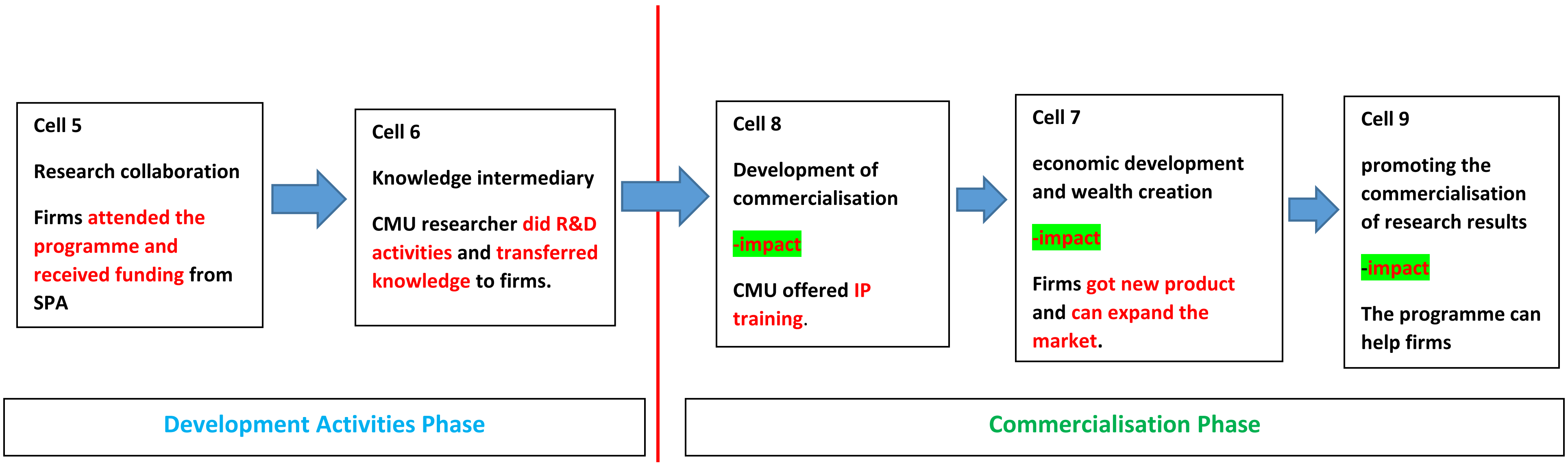
Research Question 3a: What are the roles of the university in its relationships between RIS, university and science park actors in innovation projects conducted with on-park firms? Research Question 3b: How does the university contribute to the innovation activities of on-park firms in the context of a peripheral developing economy?	
	University + SP or Interorganisational relations **(Applied Research)**
Resource Sharing	**(Cell 3)** **Provision of infrastructure (5 minutes)** What CMU infrastructure did you use in the project with the firm, how was this used and where were the research activities physically located? (The question was inspired by the matrix.)
Brokerage Role	**(Cell 6)** **Knowledge intermediaries (5 minutes)** Did the CMU researcher offer you knowledge that helped solve problems related to the project and if so what and how? (The question was inspired by the matrix.)
Exploitation and Commercialisation	**(Cell 9)** - **Start-ups creation** (incubator) - **Promoting the commercialisation of research results (5 minutes)** In your perception do you think the project was successful or not, in what ways, and why? (The question was inspired by the matrix.)

Appendix 2: The Interactive Innovation Processes Identified from Phases 1 and 2

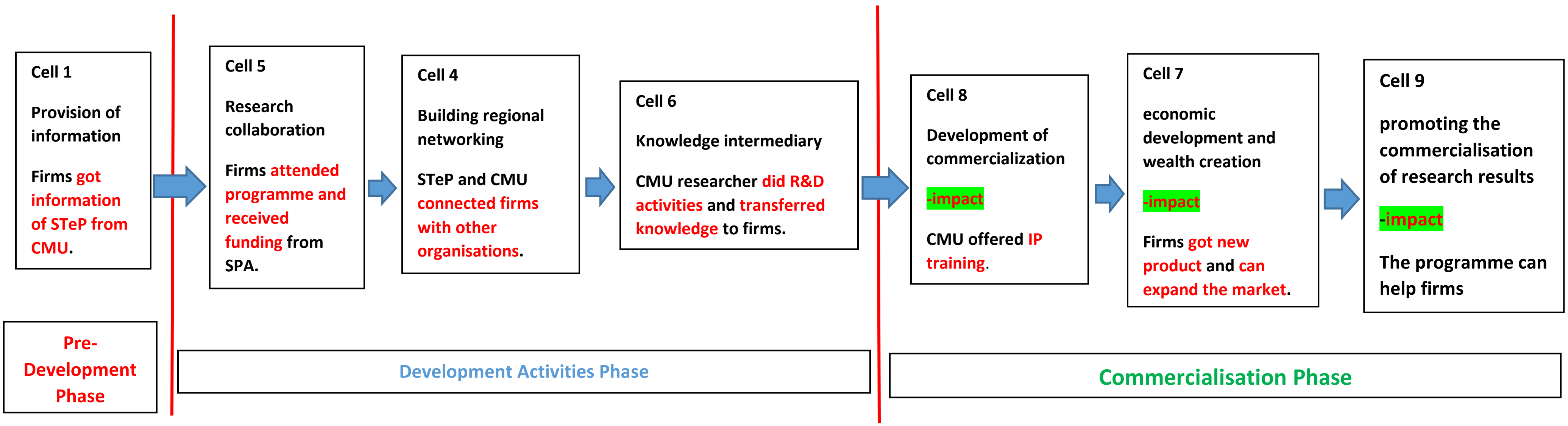
Research Relationship Process (emphasising cell 5)



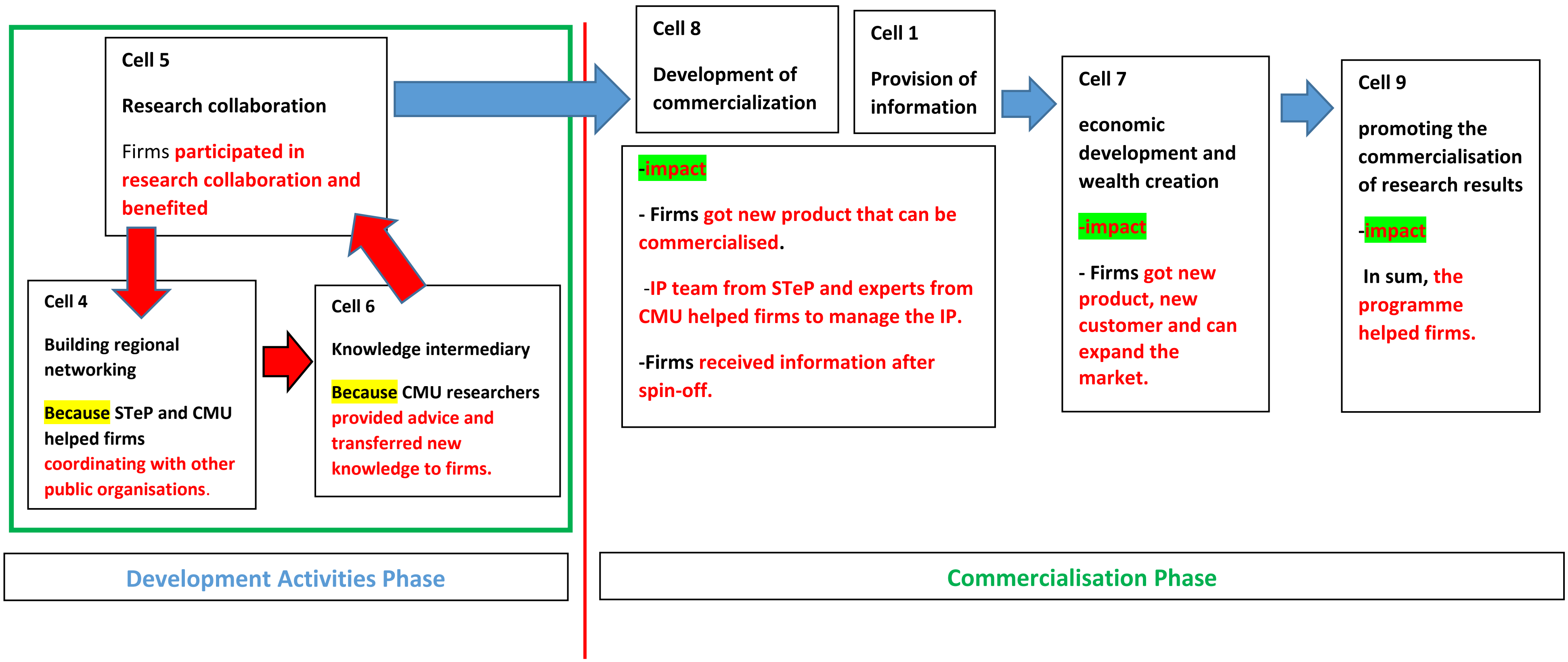
Product Development Process (emphasising cell 8)



Knowledge Transfer Process (emphasising cell 6)



Impact Process (emphasising cell 9)



Appendix 3: Research Ethics

UNIVERSITY OF PORTSMOUTH

13st December 2017
Thunyanun Theera-Nattapong
Doctoral Researcher
Strategy, Enterprise and Innovation
Faculty of Business and Law

Dear Thunyanun

Study Title:	**The Regional Innovation System-University–Science Park Nexus: A Case Study of Chiang Mai University in Thailand**
Ethics Committee reference:	**E485**

Thank you for submitting your documents for ethical review. The Ethics Committee was content to grant a favourable ethical opinion of the above research on the basis described in the application form, protocol and supporting documentation, revised in the light of any conditions set, subject to the general conditions set out in the attached document, and with the following stipulation:

The favourable opinion of the EC does not grant permission or approval to undertake the research. Management permission or approval must be obtained from any host organisation, including University of Portsmouth, prior to the start of the study.

Summary of any ethical considerations:

-

Documents reviewed

The documents reviewed by Caroline Cox [LCM] + BaL Ethics Committee

Document	Date	Version No.
Application Form	28/11/2017	1
Invitation Letter • Individual • Organisation	28/11/2017	1
Participant Information Sheet(s) (list if necessary) • Entrepreneurs of on-park firms • Organisations • Policy and Plan Analysts • Researchers of CMU • Entrepreneurs of spin-off firms • University–Science Park Executives	28/11/2017	1
Consent Form(s) (list if necessary) • Individuals • Organisations	28/11/2017	1
Application Form	11/12/2017	2
Invitation Letter • Individual • Organisation	11/12/2017	2
Participant Information Sheet(s) (list if necessary) • Entrepreneurs of on-park firms • Organisations • Policy and Plan Analysts • Researchers of CMU	11/12/2017	2

• Entrepreneurs of spin-off firms • University–Science Park Executives		
Consent Form(s) (list if necessary) • Individuals • Organisations	11/12/2017	2

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements set out by the University of Portsmouth.

After ethical review

Reporting and other requirements

The attached document acts as a reminder that research should be conducted with integrity and gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Notification of serious breaches of the protocol
- Progress reports
- Notifying the end of the study

Feedback

You are invited to give your view of the service that you have received from the Faculty Ethics Committee. If you wish to make your views known please contact the administrator, Christopher Martin.

Please quote this number on all correspondence: E485

Yours sincerely and wishing you every success in your research

Chair

Email:

Enclosures: *"After ethical review – guidance for researchers"*

After ethical review – guidance for researchers

This document sets out important guidance for researchers with a favourable opinion from a University of Portsmouth Ethics Committee. Please read the guidance carefully. A failure to follow the guidance could lead to the committee reviewing and possibly revoking its opinion on the research.

It is assumed that the research will commence within 3 months of the date of the favourable ethical opinion or the start date stated in the application, whichever is the latest.

The research must not commence until the researcher has obtained any necessary management permissions or approvals – this is particularly pertinent in cases of research hosted by external organisations. The appropriate head of department should be aware of a member of staff's research plans.

If it is proposed to extend the duration of the study beyond that stated in the application, the Ethics Committee must be informed.

If the research extends beyond a year then an annual progress report must be submitted to the Ethics Committee.

When the study has been completed the Ethics Committee must be notified.

Any proposed substantial amendments must be submitted to the Ethics Committee for review. A substantial amendment is any amendment to the terms of the application for ethical review, or to the protocol or other supporting documentation approved by the Committee that is likely to affect to a significant degree:

(a) the safety or physical or mental integrity of participants

(b) the scientific value of the study

(c) the conduct or management of the study.

A substantial amendment should not be implemented until a favourable ethical opinion has been given by the Committee.

Researchers are reminded of the University's commitments as stated in the Concordat to Support Research Integrity viz:

- maintaining the highest standards of rigour and integrity in all aspects of research
- ensuring that research is conducted according to appropriate ethical, legal and professional frameworks, obligations and standards
- supporting a research environment that is underpinned by a culture of integrity and based on good governance, best practice and support for the development of researchers
- using transparent, robust and fair processes to deal with allegations of research misconduct should they arise
- working together to strengthen the integrity of research and to reviewing progress regularly and openly

In ensuring that it meets these commitments the University has adopted the UKRIO Code of Practice for Research. Any breach of this code may be considered as misconduct and may be investigated following the University Procedure for the Investigation of Allegations of Misconduct in Research.

Researchers are advised to use the UKRIO checklist as a simple guide to integrity.

University of Portsmouth

Application for Ethical Review – Staff and Postgraduate Students

1. Study Title and Key Dates

1.1 Title
The Regional Innovation System–University–Science Park Nexus: A Case Study of Chiang Mai University in Thailand
1.2 Key Dates
Date of submission: 11/12/2017 Version Number: 2 Ethics Committee Reference Number: E485 Intended Start Date of Data Collection: 02/01/2018 Projected Finish Date of Data Collection: 30/6/2018

2. Applicant Details

2.1 Principal Investigator	
Name: Thunyanun Theera-nattapong Title /Role /Course of study: Doctoral Researcher /PhD Department: Strategy, Enterprise and Innovation Faculty: Faculty of Business and Law Telephone: 07835158405 Email: thunyanun.theera-nattapong@myport.ac.uk	
Has the principal investigator attended the graduate school (for students) or researcher development programme (for staff) research ethics training session?	Yes : 29/11/2016
2.2 Supervisor (if Principal Investigator is a student)	
Name: Professor David Pickernell Title /Role: Professor of Small Business and Enterprise Development Department: Strategy Enterprise and Innovation Faculty: Faculty of Business and Law Telephone: 02392844184 Email: david.pickernell@port.ac.uk	

Names and email of any other supervisors: Second Supervisor's Name: Dr Chris Simms Telephone: 02392844816 Email: chris.simms@port.ac.uk Third Supervisor's Name: Professor Paul Trott Telephone: 02392844245 Email: paul.trott@port.ac.uk	
Has the supervisor attended the researcher development programme research ethics training session?	Yes: First Supervisor has undertaken Epigeum online Ethics 1 (20/06/17) & 2 (09/08/17)
2.3 Others involved in the work/research including students and/or external collaborators (name, organisation/course, role in the project)	
N/A	

3. Details of Peer Review

This research will be peer-reviewed by supervisory team including

1st Reviewer Name: : Professor David Pickernell Tel: 02392844184 Email: david.pickernell@port.ac.uk

2nd Reviewer Name: Dr Chris Simms Tel: 02392844816 Email: chris.simms@port.ac.uk

3rd Reviewer: Professor Paul Trott Tel: 02392844245 Email: paul.trott@port.ac.uk

4. Funding Details

The Royal Thai Government Scholarship

5. Sites/Locations

1. Chiang Mai University (CMU), 239 Huay Kaew Road, Muang District, Chiang Mai, Thailand, 50200
2. Science and Technology Park of Chiang Mai University (CMU STeP), 2nd Floor of Research and Technology Transfer (RTT) Building: The Faculty of Engineering, 239 Huay Kaew Road, Muang District, Chiang Mai, Thailand, 50200
3. Science Park Promotion Agency (SPA), the Ministry of Science and Technology (MOST), 75/47 Rama VI Rd, Ratchathewi, Bangkok, Thailand, 10400

6. Insurance/indemnity Arrangements

Standard university insurance arrangements will apply. For travel, researcher has comprehensive insurance.

7. Aims and Objectives/Hypothesis

7.1 Aims
• Overall Aims of the Research • To develop a two-dimensional matrix illustrating the roles of the university during its RIS–university, RIS–university–science park, and university–science park relationships (completed as part of literature review) • To use this matrix to analyse the roles of the university, the linkages between actors, and the factors affecting the roles of university in Northern Thailand region chosen as the focus of the study (Research Phase 1) • To contribute to the literature on science parks, RIS, and linking both literatures together by providing evidence from RIS–university–science park case study innovation projects in the specific region of Thailand chosen for the study (Research Phase 2)
7.2 Primary Objective
To explore the roles of the university and the links between the actors in the Regional Innovation System (RIS) - university - science park nexus.
7.3 Secondary Objective(s)
N/A

8. Study Summary

8.1 Justification/Summary of Study (no more than one side)
This research focuses on the roles of the university and the links between the actors in the Regional Innovation System (RIS) - university - science park nexus in Northern Thailand, chosen as the focus of the study. Also, it will demonstrate the differences and similarities between the roles of the university and the relationships in the specific region of Thailand compared with those from the existing literature. The research defines the geographical perspective and interaction within Chiang Mai University (CMU), Thailand, as a surrogate of RIS. Having identified Thailand as the geographical focus, the three research questions are as follows. RQ 1: What are the specific roles of the university and relationships between RIS, university and science park actors in Northern Thailand? RQ 2: How do the roles of the university and the relationships between RIS, university and science park actors in projects between university and on-park firms affect the commercialisation of research results in Northern Thailand?

RQ 3: What are the unique characteristics of the roles of the university and the relationships between RIS, university and science park actors in the specific region of Thailand?

To answer the research questions, three phases of research design, which came from RQ1, 2, and 3, respectively, will be employed.

8.2 Anticipated *Ethical* Issues

- Autonomy and Non-maleficence

  Considerable efforts will be made to maintain confidentiality of data collected. Identities of participants will be kept confidential through the use of coding in transcripts, the thesis, and any future publications. The interviews will be conducted only by the researcher and data will be used for research purposes only.

  The researcher can access a University of Portsmouth secure Google Drive from Thailand through a password protected computer (and if this access is not available the password protected computer will be used to store the data prior to upload). Audio recordings will be transcribed verbatim and held as a document in a University of Portsmouth secure Google Drive alongside all notes and other documentary evidence obtained from the participants. All audio recordings, transcripts, notes, and materials provided by the participants will be password-protected and securely stored on the University of Portsmouth Google Drive during the research process. The copied documents will be stored in locked filing cabinets.

  Risks may be perceived in terms of disclosing confidential information about the workplace that individuals work for. The researcher will try to avoid this by giving participants the opportunity for voluntary participation in the study after reading the information sheet in case they would not feel comfortable answering questions related to relationships concerning the RIS-university–science park nexus. If they decide to participate, the researcher will inform them about aims of the study ensuring informed consent at individual level is reached. Potential risks will be also managed by ensuring the anonymity of participants in academic publications concerned.

8.3 Anticipated other *Risks or Concerns*

There are no risks to participants or the researcher in terms of psychological well-being, travelling, reputational risks etc.

8.4 Medical Cover (if applicable)

Medical Information: N/A

a. Medical Category (1-5):

Category 1 Paramedic or medic in attendance as determined by the IMO.

Category 2 First aider present. A 12 lead ECG is required pre-testing if: participants are beyond their 30th birthday; they display any other questionable characteristics; they have a family history of sudden death; they have no previous experience of maximum exercise. The ECG is to be reviewed by the IMO.

Category 3	First aider present
Category 4	First aider available for consultation (present within the building)
Category 5	No first aid cover required

b. Independent Medical Officer (IMO):

c. Medical cover provided by:

d. All procedures within Schedule of Approved Procedures (e.g., DSES): Yes/No*

If "No", please give brief details here.

9. Description of Method/ Protocol

The researcher has conducted a systematic literature review and found that many of the studies of science parks and RIS are qualitative in approach. For example; studies by Albahari, Catalano, & Landoni (2013); Chordá (1996); Vedovello (1997) used semi-structured interviews or personal interviews, whereas, the studies by Chan & Lau (2005); Hansson, Husted, & Vestergaard (2005); Ratinho & Henriques (2010); Yoon, Yun, Lee, & Phillips (2015); Zhang (2015) used multiple case study or longitudinal and comparative case studies of science parks or RISs from various countries.

This research, therefore, is planned to take place into three phases as follows:

The first phase will consist of semi-structured interviews with the three key groups of informants including (1) entrepreneurs in on-park firms, (2) executives of the university–science park, (3) RIS actors such as policy and plan analysts from the Science Park Promotion Agency (SPA) and entrepreneurs of spin-off firms. Documentation such as internal documents of the science park, university, and SPA, as well as published reports will also be used to supplement the data collection from semi-structured interviews. This phase aims to explore the roles of the university, the relationships between those in the RIS-university–science park nexus as well as the policies to promote the roles of the university and the relationships between them and the other key stakeholders.

The second phase will consist of in-depth study of cases of more successful and less successful projects that researchers from the university undertook with the entrepreneurs of spin-off firms to generate the commercialisation of research results. This phase aims to investigate the roles of the university and the relationships between them and entrepreneurs and to identify the factors affecting the roles of the university in generating commercialisation of research results. Again, documentation such as internal documents of the science park, university, and SPA, as well as published reports will also be used to supplement the data collection from semi-structured interviews.

The third phase was proposed in order to identify the contribution of this research that can be generalised from the knowledge gained of the RIS-university–science park nexus in the Thailand context. This phase will evaluate the observed roles of the university and relationships in the specific region of Thailand (from the first and second phases) comparing these with the existing literature.

10. Compliance with Codes, Guidance, Policies and Procedures

This research follows the 'Code of Practice for Postgraduate Research Degree'[1], issued by the University of Portsmouth in May 2016, especially in the Ethical review that is relevant to this research in terms of "No data collection or recruitment of participants can commence until ethical review has been undertaken".

1 http://policies.docstore.port.ac.uk/policy-118.pdf?_ga=2.201778708.408805713.1508363169-769010923.1494694801

11. Recruitment of Participants:

11.1 Who are the Research/ Participant Population?

The researcher has conducted a systematic literature review. Many of the studies on science parks and RIS recruit participants who hold the key roles in science park and university. These include the managers of science parks, managers of national associations of science parks, directors of technology transfer offices (TTOs) at universities involved in a science park and expert/scholars of science parks both at national and local level (Albahari et al., 2013), as well as from the management of the park, the R&D managers of (sample of) on-park firms and (sample of) researchers from the university (Vedovello, 2002).

This research, therefore, will followed the existing literature to recruit the informants based on their key role in the RIS. There will be two phases involved with the recruitment of the participants.

The first phase will consist of:

(1) entrepreneurs of on-park firms (to acquire information of their motivations to participate with the science park and university, received services and the relationship experience with these two actors)

(2) executives of university–science park (to obtain the perspectives of the roles and interaction between university and science park, and the involved policy to promote the linkage between these two actors). These actors play dual roles as they are also part of the university hierarchy

(3) RIS actors such as the policy and plan analysts from the Science Park Promotion Agency (SPA) and the entrepreneurs of spin-off firms (to get the information of the interactions and the observed roles played by university, also, the policymakers will give the details of policies to promote the linkages within the science park-university-RIS nexus)

The second phase will consist of:

(1) Researchers from the university involved in chosen projects and

(2) Entrepreneurs of spin-off firms who participated in programmes provided by the science park (such as Business Incubator, IRTC (Industrial Research and Technology Capability Development Programme), Collaborative research, and Service platform).

The aims of this phase are to identify the roles and relationships of the university in the projects and to identify factors affecting the roles of the university in generating commercialisation of university research results.

11.2 Inclusion/Exclusion Criteria

Inclusion Criteria: In the first phase, the entrepreneurs of on-park firms should have attended the university–science park programme for at least one year. As for the executives of university–science park and the policy and plan analysts from Science Park Promotion Agency (SPA) these should be the persons who have the duty directly to the development of science park and university performance. Lastly, the entrepreneurs of spin-off firms should have graduated from the programme not more than three years ago and still have contact with university–science park staff.

In the second phase, the university researchers should be those with the main roles in the projects. The entrepreneurs of spin-off firms should have graduated from the programme not more than three years ago and are able to be contacted by university–science park staff. Moreover, spin-off firms should be firms which sell their products in the local market or present their product in international countries or sell their product in international markets or have graduated from the programme but changed the type of business or graduated from the programme but ceased the business or did not graduate from the program.

Exclusion Criteria: In the first phase, the researcher will exclude entrepreneurs of on-park firms that are newly attending the university–science park program. Executives of the university–science park and the policy and plan analysts from the Science Park Promotion Agency (SPA) that are not involved or do not have the duty directly to development of science park and university performance will be excluded. Lastly, entrepreneurs of spin-off firms that graduated from the programme of university–science park more than three years ago and / or did not have contact with university–science park staff will also be excluded.

In the second phase, researchers who did not have main roles in the projects and entrepreneurs of spin-off firms that graduated from the programme more than three years ago and / or cannot be contacted by university–science park staff will be excluded.

11.3 Number of participants (include rationale for sample size)

The researcher has conducted a systematic literature review and found that the number of participants in studies of science park and RIS varies due to the context of each study. For example; Lew, Khan, & Cozzio (2016) conducted semi-structured interviews with six interviewees with senior managers and policymakers from provincial government, firms, and academic institution. In contrast, Hommen, Doloreux, & Larsson (2006) conducted 50 interviews in their case study of Mjärdevi Science Park, and Díez-Vial & Montoro-Sánchez (2016) conducted overall 76 interviews in their case study of the Madrid Science Park.

Also, the number of case studies in the literature of science park and RIS also varies. For example; Hansson, Husted, & Vestergaard (2005) selected two in-depth case studies of science parks in Denmark and the UK, while Chan & Lau (2005) conducted multiple case study research in Hong Kong by collecting data from incubating companies.

Given this variety, the number of planned participants in this research is as follows;

The first phase will consist of 16 face-to-face semi-structured interviews (minimum) with entrepreneurs of on-park firms (4 persons (minimum), executives of university–science parks (5 persons), policy and plan analysts from Science Park Promotion Agency (SPA) (3 persons) and entrepreneurs of spin-off firms (4 persons (minimum). This number will be sufficient to achieve a broad range of perceptions of the roles of the university and the relationships in the RIS-university–science park nexus and the policies to promote the roles of the university and its relationships. This sample was arrived at after discussion with the supervisory team, based on the availability of spin-off firms and on-park firms due to the science park being newly established in 2013 limiting the number of spin-off and on-park firms.

In the second phase, case study part will be conducted approximately 30 interviews (2 interviews per in-depth case study (15 case studies have been identified as a maximum number)) in order to construct in depth-case studies of more successful and less successful projects that the researchers from the university undertook with spin-off firms. The number of cases has been chosen based on the availability of spin-off firms due to the science park being newly established in 2013 limiting the total number of spin-off firms.

11.4 Recruitment Strategy (including details of any anticipated use of a gatekeeper in host organisations to arrange/distribute participant invitations)

The first phase:

First contact will be with the first gatekeeper who is the director of Science Park Promotion Agency (SPA). The first gatekeeper will be involved in the recruitment process of the policy and plan analysts through purposive expert sampling. After that the researcher will contact with the second gatekeeper who is the director of university–science park executives. The second gatekeeper will also be involved in the recruitment process of the entrepreneurs of on-park firms, the entrepreneurs of spin-off firms, and the executives of university–science park. As for the entrepreneurs of on-park firms and the entrepreneurs of spin-off firms, they will be contacted through the second gatekeeper on their existing contacts as well as personal contacts using convenience sampling. The executives of the university–science park will be recruited through expert sampling.

In this phase, the consent form, the invitation, and information sheet will be sent in English by the gatekeepers to the participants. Where they reply with confirmation to participate in the research by signing the form and sending the form back to the researcher (via email) or by signing the form before the interviewing, then the data collection will be started.

The second phase:

The researchers and the entrepreneurs of spin-off firms will be recruited via the second gatekeeper using expert sampling and the availability of the entrepreneurs of spin-off firms from their existing contacts as well as personal contacts using convenience sampling.

In this phase, the consent form, the invitation and information sheet will be sent in English by the second gatekeeper to the participants. When they reply with confirmation to participate in the research by signing the form and sending the form back directly to researcher (via email) or by signing before the interviewing, then the data collection will be started.

The first gatekeeper: Miss Tipawan Wetchagarun

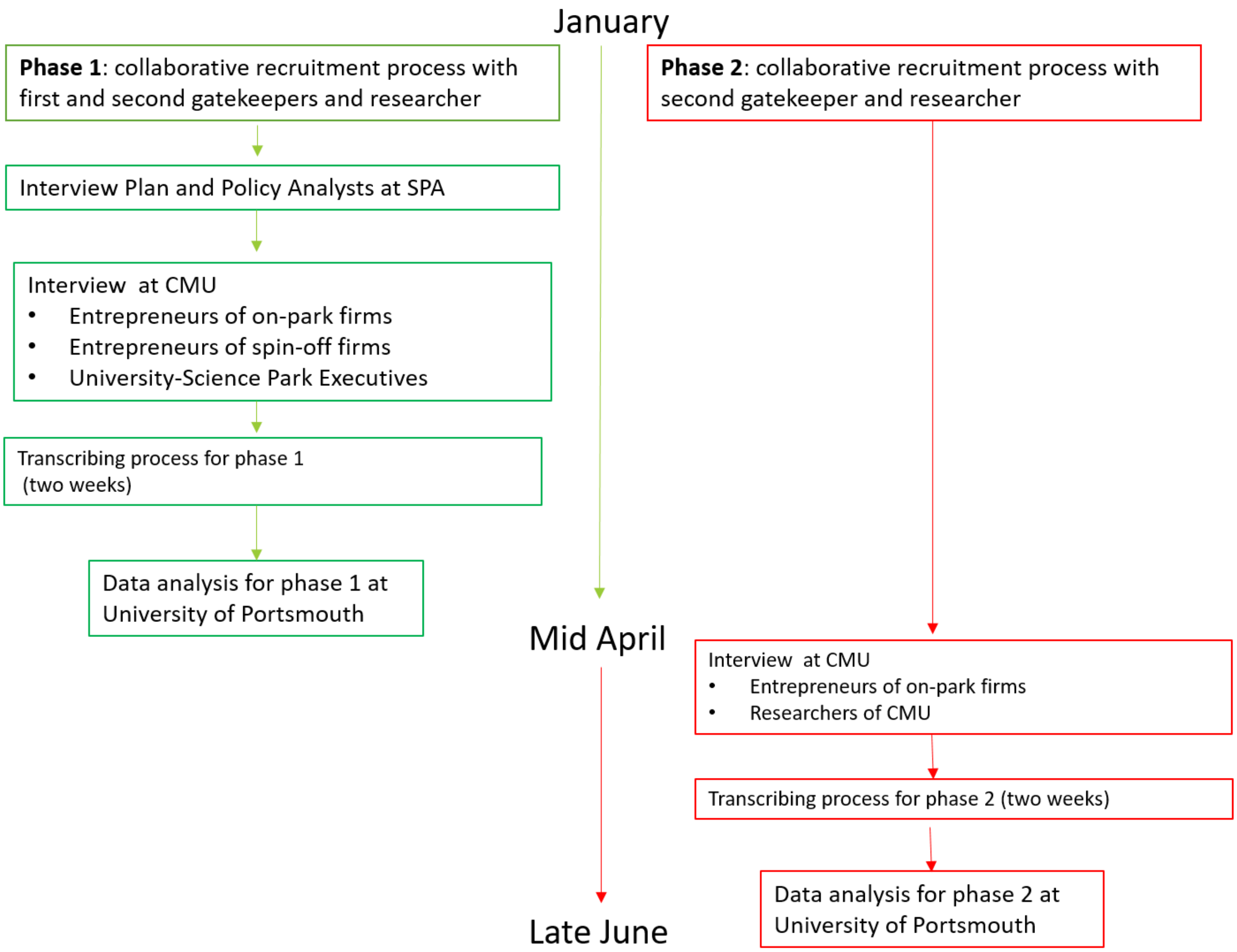
Email: tipawan@most.go.th

The second gatekeeper: Assistant Professor Dr Tanyanuparb Anantana

Email: tanyanuparb@step.cmu.ac.th

Research flowchart with timeline is on the following page:

Empirical research flowchart



11.5 Payments, rewards, reimbursements or compensation to participants

The researcher cannot offer any expenses for any participants.

11.6 What is the process for gaining *consent* from participants?

Informed consent will be sought at both organisational and individual participant level. Participants will be provided with an invitation letter, information sheet, and a consent form in English due to the most of them can understand the English (see appendix 1,2 and 3). However, if some of the participants require these documents in Thai version because they do not understand the English, then these documents will be translated into Thai by the researcher. Additionally, the organisational consent (in English) will be sought from the university, science park, and the Science Park Promotion Agency (SPA) regarding use of any data that is not in the public domain.

Each participant will be given an information sheet (in English) and the researcher will explain the aims of the study and all the points covered in the information sheet. If the participant agrees to participate in the research, they will be asked to sign the consent form confirming their acceptance to be interviewed, to record their voice, and to generate the data that will be stored and used for research purposes only.

Consent will be taken as obtained once a participant signs and returns the consent form. They can also give an oral indication of interest to participate, in which case all necessary information will be provided as above. Also, the participants can reply with the confirmation to participant in the research by signing the form and sending the form back directly to researcher via email or signed at the point of being interviewed. This process of informed consent shall be completed before the start of every interview.

It will be open to the participants to withdraw their participation at any time, up to two weeks after the data has been collected. Interviews will be digitally recorded, and the researcher may also take notes during the interviews.

The oral confirmation will be captured at the start of the recording. If consent is not reconfirmed by the participant at this point, it shall be deemed to have been withdrawn and the interview will not proceed. If the participant is happy to continue with the interview but has not consented to their voice being recorded, then the interview will proceed with the researcher only taking notes.

Please see appendix 1 for participant consent sheets (individuals and organisations).

Please see appendix 2 for participant information sheets (entrepreneurs of on-park firms, organisations, policy and plan analysts, researchers of CMU, entrepreneurs of spin-off firms and university–science park executives).

Please see appendix 3 for Invitation letters (individuals and organisations).

11.7 Has or will consent be gained from other organisations involved (if applicable)?

The consent will be gained from the university, science park and the Science Park Promotion Agency (SPA) regarding use of any data that is not in the public domain. Therefore, organisational consent will be sought from the mentioned organisations before data collection. The organisational consent will be signed by the person who can offer the organisational data and has the authority to sign it.

11.8 Arrangements for translation of any documentation into another language (if applicable)?

Participants will be provided with an invitation letter, information sheet, and a consent form in English due to the most of them can understand the English (see appendix 1,2 and 3). However, if some of them require these documents in Thai version, then the documents will be translated into Thai by the researcher

Moreover, the documentation provided by the organisations will be translated from Thai to English by the researcher.

11.9 Outline how participants can withdraw (if applicable), and how data collected up to this point will be handled. Also stop criteria for specific tests (if applicable)?
Participants can withdraw their participation at any time, up to two weeks after the data has been collected. If participants would like to withdraw after some data have been collected, the participants will be asked if they are content for the data collected this far to be retained and included in the study. If the participants prefer to withdraw, the data collected will be destroyed and not included in the study. Withdrawal can be orally or in writing to the researcher without giving any reason.
11.10 Outline details of re-consent or debrief (if applicable)?
N/A

12. Data Management

12.1 Description of data analysis
The interviews will be recorded and translated from Thai to English. Hand written notes will also be taken throughout the interviews. In the first phase, the roles of the university and its links will be matched with the two-dimensional matrix identified in the literature, in order to see which roles of the university and its links (from cell 1 to cell 9) are emphasised more than others and the reasons for the emphasised roles of university and its links influencing the interaction between actors. For the in-depth case studies of the second phase, the recorded interviews will be analysed through thematic analysis by using Nvivo 11 that will identify any themes which are presented in the case. While, the documents will be analysed through content analysis. The case reports will be written up comprising both the interview transcripts and the analysis of relevant documentation. After that, the two-dimensional matrix will be used as an analytical framework to analyse the empirical data in the roles of university (cell1 to cell 8) and relationships within each case. Effective and defective factors affecting to the roles of university in generating the commercialisation of research results will also be analysed. In terms of the third phase, the evidence from the first and second phase will be compared with the existing evidence grasped from the systematic literature review approach to demonstrate the differences and similarities in the roles of university and the relationships between actors.
12.2 Where and how will data be stored?
The researcher can access a University of Portsmouth secure Google Drive from Thailand through a password protected computer (and if this access is not available a password protected computer will be used to store the data prior to upload). Audio recordings will be transcribed verbatim and held as a document in a University of Portsmouth secure Google Drive alongside all notes and other documentary evidence obtained from the participants. All audio recordings, transcripts, notes, and materials provided by the participants will be password-protected and securely stored on the University of Portsmouth Google Drive during the research process. Any copied documents will be stored in locked filing cabinets.

12.3 Destruction, Retention and Reuse of Data
At the end of the research (expected to be September 2019), all data will be archived and retained. Retention will be in line with the University of Portsmouth Research Data Management Policy which requires that research must be retained for 10 years counting from whichever is the latest of: ● Completion of the research, ● Publication date of any findings emerging from the data, ● Date of last request of the research data by a third party. At the end of whichever of the above is applicable, the retention of the data will be reviewed. The outcome of the review will determine if the data will continue to be retained and for how long, or if the data will be destroyed.
2) Personal Data – How will confidentiality be ensured (for instance will anonymisation be used)?
During transcription all data will be anonymised in order to remove reference to individual as well as the names and locations of firms. All entrepreneurs of on-park, entrepreneurs of spin-off firms, and the individual participants will be given a specific code which will be used in place of names to identify transcripts. The researcher can access a University of Portsmouth secure Google Drive from Thailand through a password protected computer. All audio recordings, transcripts, notes, materials provided by the participants and the copies of consent forms giving both codes and identifying data will be stored in separate files on the Google Drive from all other data to facilitate the security. The copied documents will be stored in locked filing cabinets.
12.5 How will organisational data (publicly unavailable data) be handled (if applicable)?
For public ally unavailable data, all data provided by the participants will be anonymised and stored in separate files on the Google Drive from all other data to facilitate the security. The copied documents will be stored in locked filing cabinets.
12.6 How will security sensitive data be handled (if applicable)?
N/A

13. Publication / Impact / Dissemination Plans

The researcher plans to publish the literature review of this research in the International Journal of Management Reviews (IJMR) based on the systematic literature review approach that the researcher conducted. Other papers, based on the qualitative research undertaken are also planned to lead to publications in journals not yet finalised.

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15. Appendices

Put N/A in version Number column if necessary

Document	**Date**	**Version No.**
Application Form	11/12/2017	2
Invitation Letter • Individual • Organisation	11/12/2017	1
Participant Information Sheet(s) (list if necessary) • Entrepreneurs of on-park firms • Organisations • Policy and Plan Analysts • Researchers of CMU	11/12/2017	2

• Entrepreneurs of spin-off firms • University–Science Park Executives		
Consent Form(s) (list if necessary) • Individuals • Organisations	11/12/2017	2
Advertisement	N/A	N/A
Peer / Independent Review	N/A	N/A
Supervisor Email Confirming Application	N/A	N/A
Evidence From External Organisation Showing Support	N/A	N/A
Terms of Reference for Steering / Advisory Group	N/A	N/A
Survey Instrument	N/A	N/A
Interview Questions / Topic List • Interview Questions Phase 1 • Interview Questions Phase 2	11/12/2017	N/A
Focus Group Questions / Topic List	N/A	N/A
Focus Group Ground Rules	N/A	N/A
Script for Oral Consent	N/A	N/A
Questionnaire	N/A	N/A
Observational Data Collection Form	N/A	N/A
Risk Assessment Form(s)	N/A	N/A
Other – please describe	N/A	N/A

16. Declaration by Principal Investigator and Supervisor (if applicable)

1. The information in this form is accurate to the best of my/our knowledge and belief and I/we take full responsibility for it.

2. I/we undertake to conduct the research/ work in compliance with the University of Portsmouth Ethics Policy, UUK Concordat to Support Research Integrity, the UKRIO Code of Practice and any other guidance I/we have referred to in this application.

3. If the research/ work is given a favourable opinion I/we undertake to adhere to the study protocol, the terms of the full application as approved and any conditions set out by the Ethics Committee in giving its favourable opinion.

4. I/we undertake to notify the Ethics Committee of substantial amendments to the protocol or the terms of the approved application, and to seek a favourable opinion before implementing the amendment.

5. I/we undertake to submit annual progress reports (if the study is of more than a year's duration) setting out the progress of the research/ work, as required by the Ethics Committee.

6. I/we undertake to inform the Ethics Committee when the study is complete and provide a declaration accordingly.

7. I/we am/are aware of my/our responsibility to be up to date and comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data, including the need to register, when necessary, with the appropriate Data Protection Officer. I/we understand that I/we am/are not permitted to disclose identifiable data to third parties unless the disclosure has the consent of the data subject.

8. I/we undertake to comply with the University of Portsmouth Data Management Policy.

9. I /we understand that records/data may be subject to inspection by internal and external bodies for audit purposes if required.

10. I/we understand that any personal data in this application will be held by the Ethics Committee, its Administrator and its operational managers and that this will be managed according to the principles established in the Data Protection Act 1998.

11. I understand that the information contained in this application, any supporting documentation and all correspondence with the Ethics Committee and its Administrator relating to the application:

- Will be held by the Ethics Committee until at least 30 years after the end of the study
- Will be subject to the provisions of the Freedom of Information Acts and may be disclosed in response to requests made under the Acts except where statutory exemptions apply.
- May be sent by email or other electronic distribution to Ethics Committee members.

Principal Investigator ...Thunyanun Theera-nattapong Date……27/11/17……………….

DGPickernell

Supervisor (if applicable) Date…27/11/17…………………

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University of Portsmouth

Participant Information Sheet: Entrepreneurs of on-park firms

Title of Project: The Regional Innovation System–University–Science Park Nexus: A Case Study of Chiang Mai University in Thailand

Ethics Committee Reference Number: ......**E485**.............

I would like to invite you to take part in my research study. Joining the study is entirely up to you. Before you decide I would like you to understand why the research is being done and what it would involve for you. I will go through this information sheet with you, to help you decide whether or not you would like to take part and answer any questions you may have. I would suggest this should take about 5 minutes. Please feel free to talk to others about the study if you wish. Do ask if anything is unclear.

I am PhD student conducting research on the roles of university and the relationships between the stakeholders in the Regional Innovation System (RIS)–University–Science Park Nexus. This study is concerned with the roles of the university and the links between the actors in order to close research gaps and contribute to the literature on science parks, RIS, and linking both literatures together by providing evidence from RIS–University–Science Park interactions in the specific region of Thailand chosen for the study.

I am seeking participants who should be the entrepreneurs of on-park firms that attended the university–science park programme at least one year or more ago. Participation in the research would require you to attend the interview and take approximately 1 hour of your time.

What is the purpose of the study?

This research has three aims including

1) to develop a two-dimensional matrix illustrating the roles of the university during its RIS–university, RIS–university–science park, and university–science park relationships.

2) To use this matrix to analyse the roles of the university, the linkages between actors, and the factors affecting the roles of the university in Northern Thailand region chosen as the focus of the study.

3) To contribute to the literature on science parks, RIS, and linking both literatures together by providing evidence from RIS–University–Science Park case study innovation projects in the specific region of Thailand chosen for the study

Why have I been invited?

I asked the gatekeepers to help me identify relevant individuals to participate in the study. You are invited because you are an entrepreneur who attended the university–science park programme at least one year or more ago. Therefore, you are a potential knowledgeable respondent, who can significantly contribute by answering the questions.

Do I have to take part?

No, taking part in this research is entirely voluntary. It is up to you to decide if you want to volunteer for the study. We will describe the study in this information sheet. If you agree to take part, we will then ask you to sign the attached consent form, dated 11/12/2017, version number, 2.

What will happen to me if I take part?

Individuals will be asked to take part in an individual interview to express their personal experience and views on this subject matter. A list of questions will be asked to the interviewees, and the questions might be changed slightly from one interview to another depending on the response of the interviewees. The research process will last for 1 year and therefore you might be asked for an additional interview if further questions arise following the first interview. The interview will include the researcher taking notes.

Both organisation and individual consent forms emphasise that the information collected might be shared with authorised people for academic purposes only. Collected data (recorded interviews, copies of documents) will be transferred to a computer. Collected data will be summarised, all computer files will be password-protected and written notes immediately disposed of. The consent will also include that the information collected will be saved securely as it might be needed for future academic publications (PhD thesis, journal articles, book chapters, conference presentations). At the end of the research (expected to be September 2019), all data will be archived / retained / destroyed in line with the University of Portsmouth Research Data Management Policy. Neither your organisation nor any participants will be identified by name or job title and none of the responses you provide will be reported in a form that can be used to identify you. The rules will apply in my PhD thesis and any other academic publications, and additionally the name of the firms and its brands will also be disguised.

Expenses and payments

The interview will be take place at a time and location which is convenient to you at your place of work. I am afraid I can offer no expenses for your participation.

What data will be collected and / or measurements taken?

The research is planned to take place into three stages as follows:

The first phase will consist of semi-structured interviews with the three key groups of informants including (1) the entrepreneurs of on-park firms, (2) the executives of the university–science park, (3) RIS actors such as the policy and plan analysts from Science Park Promotion Agency (SPA) and the entrepreneurs of spin-off firms. Documentation such as internal documents of the science park, university, and SPA, as well as published reports will also be used to supplement the data collection from semi-structured interviews. This phase aims to explore the roles of the university and relationships in the RIS-university–science park nexus as well as the policies to promote the roles of the university and relationships between stakeholders.

The second phase will consist of in-depth cases of more successful and less successful projects that researchers from the university undertook with entrepreneurs of spin-off firms to generate commercialisation of research results. This phase aims to investigate the roles of the university and its relationships and to identify the factors affecting the roles of university in generating the commercialisation of research results. Also, documentation such as internal documents of the science park, university, and SPA, as well as published reports will be used to supplement the data collection from semi-structured interviews.

The third phase will identify the contribution of this research that can be generalised on the knowledge of RIS-university–science park nexus. This phase will present the observed roles of the university and its relationships in the specific region of Thailand (from the first and second phases) comparing these with those from the existing literature.

What are the possible disadvantages, burdens and risks of taking part?

There are no risks to participants in terms of the psychological well-being, travelling, reputational risks etc.

The interviews will not exceed 1 hour. The researcher will adjust the schedule to ensure availability and a convenient location for the participant.

The reputation of the organisation will be protected by ensuring the anonymity of the organisation, its brands and its staff in all publications. In all academic publications, the organisation and its brands will not be identified. The names and job titles of all participating individuals will not be given in academic publications. All data collected will be held securely to ensure the confidentiality of the organisation and its staff.

What are the possible advantages or benefits of taking part?

The possible benefits of this research are that we will have a fuller understanding the roles of Chiang Mai University, the linkages between RIS–University–Science Park in Northern Thailand and the factors affecting the roles and relationships of the university in generating the commercialisation of research results.

Will my taking part in the study be kept confidential?

While making summaries and storing notes all data will be anonymised to remove reference to individual names and locations of on-park and spin-off firms. All individual participants will be given a specific code, which will be used in place of names, to identify the notes. Copies of consent forms giving both codes and identifying data will be stored in separate files from all other data to facilitate the security of companies and individuals. Also, the researcher can access a University of Portsmouth secure Google Drive from Thailand through a password protected computer.

The raw data, which identifies you, will be kept securely by the researcher and / or supervisor. All audio recordings, transcripts, notes, and materials provided by the participants will be password-protected where possible and securely stored on the University of Portsmouth Google Drive during the research process. The copied documents will be stored in locked filing cabinets.

The data, when made anonymous and after analysis, may be presented to others at academic conferences, or published in a project report, academic dissertation or in academic journals or book. It could also be made available to The Royal Thai Government. Anonymous data, which does not identify you, may be used in future research studies approved by an appropriate research ethics committee.

The raw data, which would identify you, will not be passed to anyone outside the study team without your express written permission. The exception to this will be any regulatory authority which may have the legal right to access the data for the purposes of conducting an audit or enquiry, in exceptional cases. These agencies treat your personal data in confidence.

The raw data will be retained for up to 10 years. When it is no longer required, the data will be disposed of securely (*e.g.,* electronic media and paper records / images) destroyed.

What will happen if I don't want to carry on with the study?

As a volunteer, you can withdraw from the study at any time up to two weeks after the interview, without giving a reason if you do not wish to. If you do withdraw from a study after data has been collected, you will be asked if you are content for the data collected thus far to be retained and included in the study. If you prefer to withdraw, the data collected can be destroyed and not included in the study.

What if there is a problem?

If you have a query, concern or complaint about any aspect of this study, in the first instance you should contact the researcher if appropriate. As the researcher is a student, there is also an academic member of staff listed as the supervisor who you are able to contact. If there is a complaint, please contact the Supervisor with details of the complaint. The contact details for both the researcher and any supervisor are detailed on page 1.

If your concern or complaint is not resolved by the researcher or their supervisor, you should contact Dr Renatas Kizys, Faculty Research Degree Coordinator (+44 23 9284 4635 / renatas.kizys@port.ac.uk). If the complaint remains unresolved, please contact:

The University Complaints Officer

+44 23 9284 3642 complaintsadvice@port.ac.uk

Who is funding the research?

This research is being funded by The Royal Thai Government. None of the researchers or study staff will receive any financial reward by conducting this study, other than their normal salary / bursary as an employee / student of the University.

Who has reviewed the study?

Research involving human participants is reviewed by an ethics committee to ensure that the dignity and well-being of participants is respected. This study has been reviewed by the Portsmouth Business School Faculty Ethics Committee and been given favourable ethical opinion.

Thank you

Thank you for taking time to read this information sheet and for considering volunteering for this research. If you do agree to participate your consent will be sought; please see the accompanying consent form. You will then be given a copy of this information sheet and your signed consent form, to keep.

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University of Portsmouth

Participant Information Sheet: Organisations

Title of Project: The Regional Innovation System–University–Science Park Nexus: A Case Study of Chiang Mai University in Thailand

Ethics Committee Reference Number: ......**E485**............

I would like to invite you to take part in my research study. Joining the study is entirely up to you, before you decide I would like you to understand why the research is being done and what it would involve for you. I will go through this information sheet with you, to help you decide whether or not you would like to take part and answer any questions you may have. I would suggest this should take about 5 minutes. Please feel free to talk to others about the study if you wish. Do ask if anything is unclear.

I am PhD student conducting research on the roles of university and the relationships between the Regional Innovation System (RIS)–University–Science Park Nexus. This study is concerned with the roles of the university and the links between the actors in order to fill the research gaps and contribute to the literature on science parks, RIS, and linking both literatures together by providing evidence from RIS–University–Science Park interactions in the specific region of Thailand chosen for the study. Participation in the research would require you to provide the documentation such as internal documents or published reports that will be used as supplement the data collection.

What is the purpose of the study?

This research has three aims including

1) to develop a two-dimensional matrix illustrating the roles of the university during its RIS–university, RIS–university–science park, and university–science park relationships.

2) To use this matrix to analyse the roles of the university, the linkages between actors, and the factors affecting the roles of university in Northern Thailand region chosen as the focus of the study.

3) To contribute to the literature on science parks, RIS, and linking both literatures together by providing evidence from RIS–University–Science Park case study innovation projects in the specific region of Thailand chosen for the study

Why has my organisation been invited?

Because your organisation involved in the RIS-university–science park interaction in Northern Thailand and the documentation from your organisation such as internal documents as well as published reports can be use as supplement the data collection.

Does my organisation have to take part?

No, taking part in this research is entirely voluntary. It is up to you to decide if you want to volunteer for the study. We will describe the study in this information sheet. If you agree to take part, we will then ask you to sign the attached consent form, dated 11/12/2017, version number, 2.

What will happen to the organisation and our staff if we take part?

I asked the gatekeepers to help me identify relevant staff to participate in the study.

Individuals will be asked to take part in an individual interview to express their personal experience and views on this subject matter. A list of questions will be asked to the interviewees, and the questions might be changed slightly from one interview to another depending on the response of the interviewees. The research will last for 1 year therefore you might be asked for an additional interview if there would arise any further questions following the first interview. The interview will include taking notes by the researcher. The documentation such as internal documents of science park, university, and SPA, as well as published reports will also use as supplement the data collection.

The second part of the study includes in-depth case studies of more successful and less successful projects that firms did with the researchers from the university. Therefore, I might require interviews with several different researchers and entrepreneurs of spin-off firms, who were involved in the chosen project within the science park programmes, to help me understand the roles of university and the relationships to generate the commercialisation of research results. The documentation such as internal documents of science park, university, and SPA, as well as published reports will also use as supplement the data collection.

Both organisation and individual consent forms emphasise that the information collected might be shared with authorised people for academic purposes. Collected data (recorded interviews, copies of documents) will be transferred to a computer. Collected data will be summarised to computer, all computer files will be password-protected and notes immediately disposed of. The consent will also include that the information collected will be saved securely as it might be needed for future academic publications (PhD thesis, journal articles, book chapters, conference presentations). As soon as the research and publications are completed all data collected will be erased.

Neither your organisation nor any participants will be identified by name or job title and none of the responses you provide will be reported in a form that can be used to identify you. The rules will apply in my PhD thesis and any other academic publications, and additionally the name of the firms and its brands will also be disguised.

Expenses and payments

The interview will be take place at a time and location which is convenient to you at your place of work. I am afraid I can offer no expenses for your participation.

What data will be collected and / or measurements taken?

The research is planned to take place into three stages as follows:

The first phase will consist of semi-structured interviews with the three key groups of informants including (1) the entrepreneurs of on-park firms, (2) the executives of university–science park, (3) RIS actors such as the policy and plan analysts from Science Park Promotion Agency (SPA) and the entrepreneurs of spin-off firms. The documentation such as internal documents of science park, university, and SPA, as well as published reports will also use as supplement the data collection from semi-structured interviews. This phase aims to explore the roles of university and the relationships between RIS-university–science park nexus as well as the policies to promote the roles of university and the relationships between them.

The second phase will consist of in-depth cases of more successful and less successful projects that researchers from university did with the entrepreneurs of spin-off firms to generate the commercialisation of research results. This phase aims to investigate the roles of university and the relationships between them and to identify the factors affecting to the roles of university in generating the commercialisation of research results. Also, documentation such as internal documents of science park, university, and SPA, as well as published reports will also use as supplement the data collection from semi-structured interviews.

The third phase was proposed in order to identify the contribution of this research that can be generalised on the knowledge of RIS-university–science park nexus. This phase will present the observed roles of university and relationships in the specific region of Thailand (from the first and second phases) comparing with those from the existing literature.

What are the possible disadvantages, burdens and risks of taking part?

There are no risks to participants in terms of the psychological well-being, travelling, reputational risks etc.

The reputation of the organisation will be protected by ensuring the anonymity of the organisation, its brands and its staff in all publications. In all academic publications, the organisation and its brands will not be identified. The names and job titles of all participating individuals will not be given in academic publications. All data collected will be held securely to ensure the confidentiality of the organisation and its staff.

What are the possible advantages or benefits of taking part?

The possible benefits of this research are that we will have a fuller understanding the roles of Chiang Mai University, the linkages between RIS–University–Science Park in Northern Thailand and the factors affecting to the roles and relationships of the university in generating the commercialisation of research results.

Will my taking part in the study be kept confidential?

While making summaries and storing notes all data will be anonymised to remove reference to individual names and locations of on-park and spin-off firms. All individual participants will be given a specific code, which will be used in place of names, to identify the notes. Copies of consent forms giving both codes and identifying data will be stored in separate files on the N drive from all other data to facilitate the security of companies and individuals. Also, the researcher can access a University of Portsmouth secure Google Drive from Thailand through a password protected computer.

The raw data, which identifies you, will be kept securely by the researcher and or supervisor. All audio recordings, transcripts, notes, and materials provided by the participants will be password-protected where possible and securely stored on the University of Portsmouth Google Drive during the research process. The copied documents will be stored in locked filing cabinets.

The data, when made anonymous, may be presented to others at academic conferences, or published as a project report, academic dissertation or in academic journals or book. It could also be made available to The Royal Thai

Government. Anonymous data, which does not identify you, may be used in future research studies approved by an appropriate research ethics committee.

The raw data, which would identify you, will not be passed to anyone outside the study team without your express written permission. The exception to this will be any regulatory authority which may have the legal right to access the data for the purposes of conducting an audit or enquiry, in exceptional cases. These agencies treat your personal data in confidence.

The raw data will be retained for up to 10 years. When it is no longer required, the data will be disposed of securely (*e.g.,* electronic media and paper records / images) destroyed.

What will happen if I don't want to carry on with the study?

As a volunteer, you can stop providing any data that is not in the public domain at any time, up to two weeks after the data have been collected without giving a reason if you do not wish to. If you do withdraw, the data collected can be destroyed and not included in the study.

What if there is a problem?

If you have a query, concern or complaint about any aspect of this study, in the first instance you should contact the researcher if appropriate. If the researcher is a student, there will also be an academic member of staff listed as the supervisor whom you can contact. If there is a complaint and there is a supervisor listed, please contact the Supervisor with details of the complaint. The contact details for both the researcher and any supervisor are detailed on page 1.

If your concern or complaint is not resolved by the researcher or their supervisor, you should contact Dr Renatas Kizys, Faculty Research Degree Coordinator (+44 23 9284 4635 / renatas.kizys@port.ac.uk). If the complaint remains unresolved, please contact:

The University Complaints Officer

+44 23 9284 3642 complaintsadvice@port.ac.uk

Who is funding the research?

This research is being funded by The Royal Thai Government. None of the researchers or study staff will receive any financial reward by conducting this study, other than their normal salary / bursary as an employee / student of the University.

Who has reviewed the study?

Research involving human participants is reviewed by an ethics committee to ensure that the dignity and well-being of participants is respected. This study has been reviewed by the Portsmouth Business School Faculty Ethics Committee and been given favourable ethical opinion.

Thank you

Thank you for taking time to read this information sheet and for considering volunteering for this research. If you do agree to participate your consent will be sought; please see the accompanying consent form. You will then be given a copy of this information sheet and your signed consent form, to keep.

PhD Researcher: Thunyanun Theera-nattapong
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Director of Study: Professor David Pickernell
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Tel: +44 23 9284 4184
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Participant Information Sheet: Policy and Plan Analysts

Title of Project: The Regional Innovation System–University–Science Park Nexus: A Case Study of Chiang Mai University in Thailand

Ethics Committee Reference Number: ......**E485**..............

I would like to invite you to take part in my research study. Joining the study is entirely up to you, before you decide I would like you to understand why the research is being done and what it would involve for you. I will go through this information sheet with you, to help you decide whether or not you would like to take part and answer any questions you may have. I would suggest this should take about 5 minutes. Please feel free to talk to others about the study if you wish. Do ask if anything is unclear.

I am PhD student conducting research on the roles of university and the relationships between the Regional Innovation System (RIS)–University–Science Park Nexus. This study is concerned with the roles of the university and the links between the actors in order to fill the research gaps and contribute to the literature on science parks, RIS, and linking both literatures together by providing evidence from RIS–University–Science Park interactions in the specific region of Thailand chosen for the study.

I am seeking participants who should be the policy and plan analysts from Science Park Promotion Agency (SPA) that have the duty directly to the development of science park and university performance, Participation in the research would require you to attend the interview and take approximately 1 hour of your time.

What is the purpose of the study?

This research has three aims including

1) to develop a two-dimensional matrix illustrating the roles of the university during its RIS–university, RIS–university–science park, and university–science park relationships.

2) To use this matrix to analyse the roles of the university, the linkages between actors, and the factors affecting the roles of university in Northern Thailand region chosen as the focus of the study.

3) To contribute to the literature on science parks, RIS, and linking both literatures together by providing evidence from RIS–University–Science Park case study innovation projects in the specific region of Thailand chosen for the study

Why have I been invited?

I asked the gatekeepers to help me identify relevant individuals to participate in the study. You are invited because you are a policy and plan analyst who have the duty directly to the development of science park and university performance; therefore, you are a potential knowledgeable respondent, who can significantly contribute in answering the questions.

Do I have to take part?

No, taking part in this research is entirely voluntary. It is up to you to decide if you want to volunteer for the study. We will describe the study in this information sheet. If you agree to take part, we will then ask you to sign the attached consent form, dated 11/12/2017, version number, 2.

What will happen to me if I take part?

Individuals will be asked to take part in an individual interview to express their personal experience and views on this subject matter. A list of questions will be asked to the interviewees, and the questions might be changed slightly from one interview to another depending on the response of the interviewees. The research will last for 1 year therefore you might be asked for an additional interview if there would arise any further questions following the first interview. The interview will include taking notes by the researcher.

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Expenses and payments

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The research is planned to take place into three stages as follows:

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What are the possible disadvantages, burdens and risks of taking part?

There are no risks to participants in terms of the psychological well-being, travelling, reputational risks etc.

The interviews will not exceed the 1 hour. Researcher will adjust to the schedule and availability and convenient location for the participant.

The reputation of the organisation will be protected by ensuring the anonymity of the organisation, its brands and its staff in all publications. In all academic publications, the organisation and its brands will not be identified. The names and job titles of all participating individuals will not be given in academic publications. All data collected will be held securely to ensure the confidentiality of the organisation and its staff.

What are the possible advantages or benefits of taking part?

The possible benefits of this research are that we will have a fuller understanding the roles of Chiang Mai University, the linkages between RIS–University–Science Park in Northern Thailand and the factors affecting to the roles and relationships of the university in generating the commercialisation of research results.

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The raw data, which identifies you, will be kept securely by the researcher and or supervisor. All audio recordings, transcripts, notes, and materials provided by the participants will be password-protected where possible and securely stored on the University of Portsmouth Google Drive during the research process. The copied documents will be stored in locked filing cabinets.

The data, when made anonymous, may be presented to others at academic conferences, or published as a project report, academic dissertation or in academic journals or book. It could also be made available to The Royal Thai Government. Anonymous data, which does not identify you, may be used in future research studies approved by an appropriate research ethics committee.

The raw data, which would identify you, will not be passed to anyone outside the study team without your express written permission. The exception to this will be any regulatory authority which may have the legal right to access the data for the purposes of conducting an audit or enquiry, in exceptional cases. These agencies treat your personal data in confidence.

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What will happen if I don't want to carry on with the study?

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What if there is a problem?

If you have a query, concern or complaint about any aspect of this study, in the first instance you should contact the researcher if appropriate. If the researcher is a student, there will also be an academic member of staff listed as the supervisor whom you can contact. If there is a complaint and there is a supervisor listed, please contact the Supervisor with details of the complaint. The contact details for both the researcher and any supervisor are detailed on page 1.

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Who is funding the research?

This research is being funded by The Royal Thai Government. None of the researchers or study staff will receive any financial reward by conducting this study, other than their normal salary / bursary as an employee / student of the University.

Who has reviewed the study?

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Thank you

Thank you for taking time to read this information sheet and for considering volunteering for this research. If you do agree to participate your consent will be sought; please see the accompanying consent form. You will then be given a copy of this information sheet and your signed consent form, to keep.

PhD Researcher: Thunyanun Theera-nattapong
Faculty of Business and Law,
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Director of Study: Professor David Pickernell
Faculty of Business and Law, University of Portsmouth,
Richmond Building, Portland Street,
Portsmouth, PO1 3DE.
Tel: +44 23 9284 4184
Email: david.pickernell@port.ac.uk

University of Portsmouth

Participant Information Sheet: Researchers of CMU

Title of Project: The Regional Innovation System–University–Science Park Nexus: A Case Study of Chiang Mai University in Thailand

Ethics Committee Reference Number: ......**E485**............

I would like to invite you to take part in my research study. Joining the study is entirely up to you, before you decide I would like you to understand why the research is being done and what it would involve for you. I will go through this information sheet with you, to help you decide whether or not you would like to take part and answer any questions you may have. I would suggest this should take about 5 minutes. Please feel free to talk to others about the study if you wish. Do ask if anything is unclear.

I am PhD student conducting research on the roles of university and the relationships between the Regional Innovation System (RIS)–University–Science Park Nexus. This study is concerned with the roles of the university and the links between the actors in order to fill the research gaps and contribute to the literature on science parks, RIS, and linking both literatures together by providing evidence from RIS–University–Science Park interactions in the specific region of Thailand chosen for the study.

I am seeking participants who should be the researchers from CMU that have the main roles in the projects between science park and firms. Participation in the research would require you to attend the interview and take approximately 1 hour of your time.

What is the purpose of the study?

This research has three aims including

1) to develop a two-dimensional matrix illustrating the roles of the university during its RIS–university, RIS–university–science park, and university–science park relationships.

2) To use this matrix to analyse the roles of the university, the linkages between actors, and the factors affecting the roles of university in Northern Thailand region chosen as the focus of the study.

3) To contribute to the literature on science parks, RIS, and linking both literatures together by providing evidence from RIS–University–Science Park case study innovation projects in the specific region of Thailand chosen for the study

Why have I been invited?

I asked the gatekeepers to help me identify relevant individuals to participate in the study. You are invited because you are a researcher of CMU who have the main roles in the projects between science park and firms; therefore, you are a potential knowledgeable respondent, who can significantly contribute in answering the questions.

Do I have to take part?

No, taking part in this research is entirely voluntary. It is up to you to decide if you want to volunteer for the study. We will describe the study in this information sheet. If you agree to take part, we will then ask you to sign the attached consent form, dated 11/12/2017, version number, 2.

What will happen to me if I take part?

Individuals will be asked to take part in an individual interview to express their personal experience and views on this subject matter. A list of questions will be asked to the interviewees, and the questions might be changed slightly from one interview to another depending on the response of the interviewees. The research will last for 1 year therefore you might be asked for an additional interview if there would arise any further questions following the first interview. The interview will include taking notes by the researcher.

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Expenses and payments

The interview will be take place at a time and location which is convenient to you at your place of work. I am afraid I can offer no expenses for your participation.

What data will be collected and / or measurements taken?

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The first phase will consist of semi-structured interviews with the three key groups of informants including (1) the entrepreneurs of on-park firms, (2) the executives of university–science park, (3) RIS actors such as the policy and plan analysts from Science Park Promotion Agency (SPA) and the entrepreneurs of spin-off firms. The documentation such as internal documents of science park, university, and SPA, as well as published reports will also use as supplement the data collection from semi-structured interviews. This phase aims to explore the roles of university and the relationships between RIS-university–science park nexus as well as the policies to promote the roles of university and the relationships between them.

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What are the possible disadvantages, burdens and risks of taking part?

There are no risks to participants in terms of the psychological well-being, travelling, reputational risks etc.

The interviews will not exceed the 1 hour. Researcher will adjust to the schedule and availability and convenient location for the participant.

What are the possible advantages or benefits of taking part?

The possible benefits of this research are that we will have a fuller understanding the roles of Chiang Mai University, the linkages between RIS–University–Science Park in Northern Thailand and the factors affecting to the roles and relationships of the university in generating the commercialisation of research results.

Will my taking part in the study be kept confidential?

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The raw data, which identifies you, will be kept securely by the researcher and or supervisor. All audio recordings, transcripts, notes, and materials provided by the participants will be password-protected where possible and securely stored on the University of Portsmouth Google Drive during the research process. The copied documents will be stored in locked filing cabinets.

The data, when made anonymous, may be presented to others at academic conferences, or published as a project report, academic dissertation or in academic journals or book. It could also be made available to The Royal Thai

Government. Anonymous data, which does not identify you, may be used in future research studies approved by an appropriate research ethics committee.

The raw data, which would identify you, will not be passed to anyone outside the study team without your express written permission. The exception to this will be any regulatory authority which may have the legal right to access the data for the purposes of conducting an audit or enquiry, in exceptional cases. These agencies treat your personal data in confidence.

The raw data will be retained for up to 10 years. When it is no longer required, the data will be disposed of securely (*e.g.,* electronic media and paper records / images) destroyed.

What will happen if I don't want to carry on with the study?

As a volunteer, you can withdraw from the study at any time up to two weeks after the interview, without giving a reason if you do not wish to. If you do withdraw from a study after data has been collected, you will be asked if you are content for the data collected thus far to be retained and included in the study. If you prefer to withdraw, the data collected can be destroyed and not included in the study.

What if there is a problem?

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Who has reviewed the study?

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Thank you

Thank you for taking time to read this information sheet and for considering volunteering for this research. If you do agree to participate your consent will be sought; please see the accompanying consent form. You will then be given a copy of this information sheet and your signed consent form, to keep.

PhD Researcher: Thunyanun Theera-nattapong
Faculty of Business and Law,
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Portsmouth, PO1 3AH.
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Director of Study: Professor David Pickernell
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Richmond Building, Portland Street,
Portsmouth, PO1 3DE.
Tel: +44 23 9284 4184
Email: david.pickernell@port.ac.uk

University of Portsmouth

Participant Information Sheet: Entrepreneurs of spin-off firms

Title of Project: The Regional Innovation System–University–Science Park Nexus: A Case Study of Chiang Mai University in Thailand

Ethics Committee Reference Number: ......**E485**............

I would like to invite you to take part in my research study. Joining the study is entirely up to you, before you decide I would like you to understand why the research is being done and what it would involve for you. I will go through this information sheet with you, to help you decide whether or not you would like to take part and answer any questions you may have. I would suggest this should take about 5 minutes. Please feel free to talk to others about the study if you wish. Do ask if anything is unclear.

I am PhD student conducting research on the roles of university and the relationships between the Regional Innovation System (RIS)–University–Science Park Nexus. This study is concerned with the roles of the university and the links between the actors in order to fill the research gaps and contribute to the literature on science parks, RIS, and linking both literatures together by providing evidence from RIS–University–Science Park interactions in the specific region of Thailand chosen for the study.

I am seeking participants who should be the entrepreneurs of spin-off firms that have graduated from the programme not more than three years ago and can be contacted by university–science park staff. Participation in the research would require you to attend the interview and take approximately 1 hour of your time.

What is the purpose of the study?

This research has three aims including

1) to develop a two-dimensional matrix illustrating the roles of the university during its RIS–university, RIS–university–science park, and university–science park relationships.

2) To use this matrix to analyse the roles of the university, the linkages between actors, and the factors affecting the roles of university in Northern Thailand region chosen as the focus of the study.

3) To contribute to the literature on science parks, RIS, and linking both literatures together by providing evidence from RIS–University–Science Park case study innovation projects in the specific region of Thailand chosen for the study

Why have I been invited?

I asked the gatekeepers to help me identify relevant individuals to participate in the study. You are invited because you are an entrepreneur of spin-off firms who have graduated from the programme not more than three years ago and can be contacted by university–science park staff; therefore, you are a potential knowledgeable respondent, who can significantly contribute in answering the questions.

Do I have to take part?

No, taking part in this research is entirely voluntary. It is up to you to decide if you want to volunteer for the study. We will describe the study in this information sheet. If you agree to take part, we will then ask you to sign the attached consent form, dated 11/12/2017, version number, 2.

What will happen to me if I take part?

Individuals will be asked to take part in an individual interview to express their personal experience and views on this subject matter. A list of questions will be asked to the interviewees, and the questions might be changed slightly from one interview to another depending on the response of the interviewees. The research will last for 1 year therefore you might be asked for an additional interview if there would arise any further questions following the first interview. The interview will include taking notes by the researcher.

The second part of the study includes in-depth case studies of more successful and less successful projects that firms did with the researchers from the university. Therefore, I might require interviews with several different researchers and entrepreneurs of spin-off firms, who were involved in the chosen project within the science park programmes, to help me understand the roles of university and the relationships to generate the commercialisation of research results. The documentation such as internal documents of science park, university, and SPA, as well as published reports will also use as supplement the data collection

Both organisation and individual consent forms emphasise that the information collected might be shared with authorised people for academic purposes. Collected data (recorded interviews, copies of documents) will be transferred to a computer. Collected data will be summarised to computer, all computer files will be password-protected and notes immediately disposed of. The consent will also include that the information collected will be saved securely as it might be needed for future academic publications (PhD thesis, journal articles, book chapters, conference presentations). As soon as the research and publications are completed all data collected will be erased.

Neither your organisation nor any participants will be identified by name or job title and none of the responses you provide will be reported in a form that can be used to identify you. The rules will apply in my PhD thesis and any other academic publications, and additionally the name of the firms and its brands will also be disguised.

Expenses and payments

The interview will be take place at a time and location which is convenient to you at your place of work. I am afraid I can offer no expenses for your participation.

What data will be collected and / or measurements taken?

The research is planned to take place into three stages as follows:

The first phase will consist of semi-structured interviews with the three key groups of informants including (1) the entrepreneurs of on-park firms, (2) the executives of university–science park, (3) RIS actors such as the policy and plan analysts from Science Park Promotion Agency (SPA) and the entrepreneurs of spin-off firms. The documentation such as internal documents of science park, university, and SPA, as well as published reports will also use as supplement the data collection from semi-structured interviews. This phase aims to explore the roles of university and the relationships between RIS-university–science park nexus as well as the policies to promote the roles of university and the relationships between them.

The second phase will consist of in-depth cases of more successful and less successful projects that researchers from university did with the entrepreneurs of spin-off firms to generate the commercialisation of research results. This phase aims to investigate the roles of university and the relationships between them and to identify the factors affecting to the roles of university in generating the commercialisation of research results. Also, documentation such as internal documents of science park, university, and SPA, as well as published reports will also use as supplement the data collection from semi-structured interviews.

The third phase was proposed in order to identify the contribution of this research that can be generalised on the knowledge of RIS-university–science park nexus. This phase will present the observed roles of university and relationships in the specific region of Thailand (from the first and second phases) comparing with those from the existing literature.

What are the possible disadvantages, burdens and risks of taking part?

There are no risks to participants in terms of the psychological well-being, travelling, reputational risks etc.

The interviews will not exceed the 1 hour. Researcher will adjust to the schedule and availability and convenient location for the participant.

What are the possible advantages or benefits of taking part?

The possible benefits of this research are that we will have a fuller understanding the roles of Chiang Mai University, the linkages between RIS–University–Science Park in Northern Thailand and the factors affecting to the roles and relationships of the university in generating the commercialisation of research results.

Will my taking part in the study be kept confidential?

While making summaries and storing notes all data will be anonymised to remove reference to individual names and locations of on-park and spin-off firms. All individual participants will be given a specific code, which will be used in place of names, to identify the notes. Copies of consent forms giving both codes and identifying data will be stored in separate files on the N drive from all other data to facilitate the security of companies and individuals. Also, the researcher can access a University of Portsmouth secure Google Drive from Thailand through a password protected computer.

The raw data, which identifies you, will be kept securely by the researcher and or supervisor. All audio recordings, transcripts, notes, and materials provided by the participants will be password-protected where possible and securely stored on the University of Portsmouth Google Drive during the research process. The copied documents will be stored in locked filing cabinets.

The data, when made anonymous, may be presented to others at academic conferences, or published as a project report, academic dissertation or in academic journals or book. It could also be made available to The Royal Thai

Government. Anonymous data, which does not identify you, may be used in future research studies approved by an appropriate research ethics committee.

The raw data, which would identify you, will not be passed to anyone outside the study team without your express written permission. The exception to this will be any regulatory authority which may have the legal right to access the data for the purposes of conducting an audit or enquiry, in exceptional cases. These agencies treat your personal data in confidence.

The raw data will be retained for up to 10 years. When it is no longer required, the data will be disposed of securely (*e.g.,* electronic media and paper records / images) destroyed.

What will happen if I don't want to carry on with the study?

As a volunteer, you can withdraw from the study at any time up to two weeks after the interview, without giving a reason if you do not wish to. If you do withdraw from a study after data has been collected, you will be asked if you are content for the data collected thus far to be retained and included in the study. If you prefer to withdraw, the data collected can be destroyed and not included in the study.

What if there is a problem?

If you have a query, concern or complaint about any aspect of this study, in the first instance you should contact the researcher if appropriate. If the researcher is a student, there will also be an academic member of staff listed as the supervisor whom you can contact. If there is a complaint and there is a supervisor listed, please contact the Supervisor with details of the complaint. The contact details for both the researcher and any supervisor are detailed on page 1.

If your concern or complaint is not resolved by the researcher or their supervisor, you should contact Dr Renatas Kizys, Faculty Research Degree Coordinator (+44 23 9284 4635 / renatas.kizys@port.ac.uk). If the complaint remains unresolved, please contact:

The University Complaints Officer

+44 23 9284 3642 complaintsadvice@port.ac.uk

Who is funding the research?

This research is being funded by The Royal Thai Government. None of the researchers or study staff will receive any financial reward by conducting this study, other than their normal salary / bursary as an employee / student of the University.

Who has reviewed the study?

Research involving human participants is reviewed by an ethics committee to ensure that the dignity and well-being of participants is respected. This study has been reviewed by the Portsmouth Business School Faculty Ethics Committee and been given favourable ethical opinion.

Thank you

Thank you for taking time to read this information sheet and for considering volunteering for this research. If you do agree to participate your consent will be sought; please see the accompanying consent form. You will then be given a copy of this information sheet and your signed consent form, to keep.

PhD Researcher: Thunyanun Theera-nattapong
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Director of Study: Professor David Pickernell
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Richmond Building, Portland Street,
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Tel: +44 23 9284 4184
Email: david.pickernell@port.ac.uk

University of Portsmouth

Participant Information Sheet: University–Science Park Executives

Title of Project: The Regional Innovation System–University–Science Park Nexus: A Case Study of Chiang Mai University in Thailand

Ethics Committee Reference Number: ......**E485**..............

I would like to invite you to take part in my research study. Joining the study is entirely up to you, before you decide I would like you to understand why the research is being done and what it would involve for you. I will go through this information sheet with you, to help you decide whether or not you would like to take part and answer any questions you may have. I would suggest this should take about 5 minutes. Please feel free to talk to others about the study if you wish. Do ask if anything is unclear.

I am PhD student conducting research on the roles of university and the relationships between the Regional Innovation System (RIS)–University–Science Park Nexus. This study is concerned with the roles of the university and the links between the actors in order to fill the research gaps and contribute to the literature on science parks, RIS, and linking both literatures together by providing evidence from RIS–University–Science Park interactions in the specific region of Thailand chosen for the study.

I am seeking participants who should be the executives of university–science park that have the duty directly to the development of science park and university performance. Participation in the research would require you to attend the interview and take approximately 1 hour of your time.

What is the purpose of the study?

This research has three aims including

1) to develop a two-dimensional matrix illustrating the roles of the university during its RIS–university, RIS–university–science park, and university–science park relationships.

2) To use this matrix to analyse the roles of the university, the linkages between actors, and the factors affecting the roles of university in Northern Thailand region chosen as the focus of the study.

3) To contribute to the literature on science parks, RIS, and linking both literatures together by providing evidence from RIS–University–Science Park case study innovation projects in the specific region of Thailand chosen for the study

Why have I been invited?

I asked the gatekeepers to help me identify relevant individuals to participate in the study. You are invited because you are a university–science park executive who have the duty directly to the development of science park and university performance; therefore, you are a potential knowledgeable respondent, who can significantly contribute in answering the questions.

Do I have to take part?

No, taking part in this research is entirely voluntary. It is up to you to decide if you want to volunteer for the study. We will describe the study in this information sheet. If you agree to take part, we will then ask you to sign the attached consent form, dated 11/12/2017, version number, 2.

What will happen to me if I take part?

Individuals will be asked to take part in an individual interview to express their personal experience and views on this subject matter. A list of questions will be asked to the interviewees, and the questions might be changed slightly from one interview to another depending on the response of the interviewees. The research will last for 1 year therefore you might be asked for an additional interview if there would arise any further questions following the first interview. The interview will include taking notes by the researcher.

Both organisation and individual consent forms emphasise that the information collected might be shared with authorised people for academic purposes. Collected data (recorded interviews, copies of documents) will be transferred to a computer. Collected data will be summarised to computer, all computer files will be password-protected and notes immediately disposed of. The consent will also include that the information collected will be saved securely as it might be needed for future academic publications (PhD thesis, journal articles, book chapters, conference presentations). As soon as the research and publications are completed all data collected will be erased.

Neither your organisation nor any participants will be identified by name or job title and none of the responses you provide will be reported in a form that can be used to identify you. The rules will apply in my PhD thesis and any other academic publications, and additionally the name of the firms and its brands will also be disguised.

Expenses and payments

The interview will be take place at a time and location which is convenient to you at your place of work. I am afraid I can offer no expenses for your participation.

What data will be collected and / or measurements taken?

The research is planned to take place into three stages as follows:

The first phase will consist of semi-structured interviews with the three key groups of informants including (1) the entrepreneurs of on-park firms, (2) the executives of university–science park, (3) RIS actors such as the policy and plan analysts from Science Park Promotion Agency (SPA) and the entrepreneurs of spin-off firms. The documentation such as internal documents of science park, university, and SPA, as well as published reports will also use as supplement the data collection from semi-structured interviews. This phase aims to explore the roles of university and the relationships between RIS-university–science park nexus as well as the policies to promote the roles of university and the relationships between them.

The second phase will consist of in-depth cases of more successful and less successful projects that researchers from university did with the entrepreneurs of spin-off firms to generate the commercialisation of research results. This phase aims to investigate the roles of university and the relationships between them and to identify the factors affecting to the roles of university in generating the commercialisation of research results. Also, documentation such as internal documents of science park, university, and SPA, as well as published reports will also use as supplement the data collection from semi-structured interviews.

The third phase was proposed in order to identify the contribution of this research that can be generalised on the knowledge of RIS-university–science park nexus. This phase will present the observed roles of university and relationships in the specific region of Thailand (from the first and second phases) comparing with those from the existing literature.

What are the possible disadvantages, burdens and risks of taking part?

There are no risks to participants in terms of the psychological well-being, travelling, reputational risks etc.

The interviews will not exceed the 1 hour. Researcher will adjust to the schedule and availability and convenient location for the participant.

The reputation of the organisation will be protected by ensuring the anonymity of the organisation, its brands and its staff in all publications. In all academic publications, the organisation and its brands will not be identified. The names and job titles of all participating individuals will not be given in academic publications. All data collected will be held securely to ensure the confidentiality of the organisation and its staff.

What are the possible advantages or benefits of taking part?

The possible benefits of this research are that we will have a fuller understanding the roles of Chiang Mai University, the linkages between RIS–University–Science Park in Northern Thailand and the factors affecting to the roles and relationships of the university in generating the commercialisation of research results.

Will my taking part in the study be kept confidential?

While making summaries and storing notes all data will be anonymised to remove reference to individual names and locations of on-park and spin-off firms. All individual participants will be given a specific code, which will be used in place of names, to identify the notes. Copies of consent forms giving both codes and identifying data will be stored in separate files on the N drive from all other data to facilitate the security of companies and individuals. Also, the researcher can access a University of Portsmouth secure Google Drive from Thailand through a password protected computer.

The raw data, which identifies you, will be kept securely by the researcher and or supervisor. All audio recordings, transcripts, notes, and materials provided by the participants will be password-protected where possible and securely stored on the University of Portsmouth Google Drive during the research process. The copied documents will be stored in locked filing cabinets.

The data, when made anonymous, may be presented to others at academic conferences, or published as a project report, academic dissertation or in academic journals or book. It could also be made available to The Royal Thai

Government. Anonymous data, which does not identify you, may be used in future research studies approved by an appropriate research ethics committee.

The raw data, which would identify you, will not be passed to anyone outside the study team without your express written permission. The exception to this will be any regulatory authority which may have the legal right to access the data for the purposes of conducting an audit or enquiry, in exceptional cases. These agencies treat your personal data in confidence.

The raw data will be retained for up to 10 years. When it is no longer required, the data will be disposed of securely (*e.g.,* electronic media and paper records / images) destroyed.

What will happen if I don't want to carry on with the study?

As a volunteer, you can withdraw from the study at any time up to two weeks after the interview, without giving a reason if you do not wish to. If you do withdraw from a study after data has been collected, you will be asked if you are content for the data collected thus far to be retained and included in the study. If you prefer to withdraw, the data collected can be destroyed and not included in the study.

What if there is a problem?

If you have a query, concern or complaint about any aspect of this study, in the first instance you should contact the researcher if appropriate. If the researcher is a student, there will also be an academic member of staff listed as the supervisor whom you can contact. If there is a complaint and there is a supervisor listed, please contact the Supervisor with details of the complaint. The contact details for both the researcher and any supervisor are detailed on page 1.

If your concern or complaint is not resolved by the researcher or their supervisor, you should contact Dr Renatas Kizys, Faculty Research Degree Coordinator (+44 23 9284 4635 / renatas.kizys@port.ac.uk). If the complaint remains unresolved, please contact:

The University Complaints Officer

+44 23 9284 3642 complaintsadvice@port.ac.uk

Who is funding the research?

This research is being funded by The Royal Thai Government. None of the researchers or study staff will receive any financial reward by conducting this study, other than their normal salary / bursary as an employee / student of the University.

Who has reviewed the study?

Research involving human participants is reviewed by an ethics committee to ensure that the dignity and well-being of participants is respected. This study has been reviewed by the Portsmouth Business School Faculty Ethics Committee and been given favourable ethical opinion.

Thank you

Thank you for taking time to read this information sheet and for considering volunteering for this research. If you do agree to participate your consent will be sought; please see the accompanying consent form. You will then be given a copy of this information sheet and your signed consent form, to keep.

PhD Researcher: Thunyanun Theera-nattapong
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Portland Building, Portland Street,
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Tel: +44 23 9284 4600
Email: thunyanun.theera-nattapong@myport.ac.uk

Director of Study: Professor David Pickernell
Faculty of Business and Law, University of Portsmouth,
Richmond Building, Portland Street,
Portsmouth, PO1 3DE.
Tel: +44 23 9284 4184
Email: david.pickernell@port.ac.uk

Invitation letter: Individual Participants

Study Title: The Regional Innovation System–University–Science Park Nexus: A Case Study of Chiang Mai University in Thailand

REC Ref No: ....**E485**................

Dear Potential Participant

My name is Thunyanun Theera-nattapong. I am a PhD student conducting research on the roles of university and the relationships between stakeholders in the Regional Innovation System (RIS)–University–Science Park Nexus.

I am interested in working with a small number of organisations to get insights into the roles of Chiang Mai University (CMU) and its relationships with the other actors in Northern Thailand, chosen as the focus of this study. Additionally, I am also interested in the roles and relationships of the university in generating the commercialisation of research results.

This letter has been forwarded by Khun Tipawan Wetchagarun or Dr Tanyanuparb Anantana who acted as gatekeepers. They have identified that you might be a suitable participant in my research. However, they have not provided me with your name, address or personal details. This letter is passed by the gatekeepers, and there are no consequences either negative or positive with regard to any service that might be provided for the potential participant.

As a researcher in the Strategy, Enterprise and Innovation department at the University of Portsmouth, I would like to invite you as a possible key contributor to participate in this research study. This study has been ethically approved by the University of Portsmouth and I have attached a copy of my ethics approval letter reference number E485 with this email. More information concerning the nature of the research is provided in the enclosed information sheet.

During the research I will be undertaking a series of semi-structured interviews. These will involve a series of questions being asked to interviewees, which may be changed slightly from one interview to another, depending on the response of interviewees. All questions will be related to the observed roles play by the university and the relationships between actors, the policies to promote the roles and relationships of university as well as effective and defective factors that are considered to be important to the roles of the university in generating the commercialisation of research results.

All information provided to me as part of the study will be held securely. No individual data will be disclosed and participant names will not be used in the final report thesis. In the same way all data will be anonymised so that no reference to individual names, names of firms or products will appear in any academic publication.

Please contact me via email or telephone if you are interested in taking part in this research. Taking part in the research is voluntary and the organisation and any individual may withdraw consent at any time, up to two weeks after the interview.

Thank you for reading this letter. Please feel free to contact me if you have any further questions.

Yours faithfully,

Thunyanun Theetra-nattapong

Strategy, Enterprise and Innovation

Faculty of Business and Law

University of Portsmouth

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Portsmouth, PO1 3DE.
Tel: +44 23 9284 4184
Email: david.pickernell@port.ac.uk

Invitation letter: Organisations

Study Title: The Regional Innovation System–University–Science Park Nexus: A Case Study of Chiang Mai University in Thailand

REC Ref No: ....**E485**............

Dear Potential Participant

My name is Thunyanun Theera-nattapong. I am a PhD student conducting research on the roles of university and the relationships between stakeholders in the Regional Innovation System (RIS)–University–Science Park Nexus.

I am interested in working with a small number of organisations to get insights into the roles of Chiang Mai University (CMU) and its relationships with the other actors in Northern Thailand, chosen as the focus of this study. Additionally, I am also interested in the roles and relationships of the university in generating the commercialisation of research results.

As a researcher in the Strategy, Enterprise and Innovation department at the University of Portsmouth, I would like to invite you as a possible key contributor to participate in this research study. This study has been ethically approved by the University of Portsmouth and I have attached a copy of my ethics approval letter reference number E485 with this email. More information concerning the nature of the research is provided in the enclosed information sheet.

My research will be undertaken in three phases. In the first phase I will be focusing on the roles of the university and the relationships with the other actors in the RIS. In the second phase, I will be exploring case studies of more successful and less successful projects that firms undertook with researchers from the university. The aim is to identify effective and defective factors related to the roles of the university in generating the commercialisation of research results. Lastly, the third phase will identify the contribution of this research that can be generalised concerning the RIS-university–science park nexus.

This phase will present the observed roles of university and relationships in the specific region of Thailand (from the first and second phases) comparing this with those from the existing literature.

I would be very grateful if I could be given access to relevant documentation, such as internal documents of the university and SPA as well as published reports, to supplement the data collected via interviews. All information provided to me as part of the study will be held securely. No individual data will be enclosed and participant names will not be used in the final report thesis. In the same way all data will be anonymised so that no reference to individual names, names of firms or products will appear in any academic publication.

Please contact me via email or telephone if you are interested in taking part in this research. Taking part in the research is voluntary and the organisation may withdraw consent at any time, up to two weeks after the data have been collected.

Thank you for reading this letter. Please feel free to contact me if you have any further questions.

Yours faithfully,

Thunyanun Theetra-nattapong

Strategy, Enterprise and Innovation

Faculty of Business and Law

University of Portsmouth

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Email: david.pickernell@port.ac.uk

University of Portsmouth

CONSENT FORM: Individuals

Title of Project: The Regional Innovation System–University–Science Park Nexus: A Case Study of Chiang Mai University in Thailand

Ethics Committee Reference Number: ......**E485**.........

Please initial box

1. I confirm that I have read and understood the information sheet dated 11/12/2017 (version 2) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, up to two weeks after the interview. ☐

3. I consent for my interview to be audio recorded. The recording will be transcribed and analysed by the researcher for the purposes of the research. ☐

4. I understand that data collected during this study, *could* be requested and looked at by regulatory authorities. I give my permission for any authority, with a legal right of access, to view data which might identify me. Any promises of confidentiality provided by the researcher will be respected. ☐

5. I understand that the aggregated overall results may be published and / or presented at meetings or academic conferences, and may be provided to the Royal Thai Government. I give my permission for my anonymous data, which does not identify me, to be disseminated in this way. ☐

6. I agree to the data I contribute being retained for any future research that has been approved by a Research Ethics Committee.

7. I agree to take part in the above study.

Name of Participant: **Date:** **Signature:**

Name of Person taking Consent: **Date:** **Signature:**

***Note**: When completed, one copy to be given to the participant, one copy to be retained in the study file*

PhD Researcher: Thunyanun Theera-nattapong
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Tel: +44 23 9284 4184
Email: david.pickernell@port.ac.uk

University of Portsmouth

CONSENT FORM: Organisations

Title of Project: The Regional Innovation System–University–Science Park Nexus: A Case Study of Chiang Mai University in Thailand

Ethics Committee Reference Number: ....**E485**.............

Please initial box

1. I confirm that I have read and understood the information sheet dated 11/12/2017 (version 2) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, up to two weeks after the interview. ☐

3. I consent for my interview to be audio recorded. The recording will be transcribed and analysed by the researcher for the purposes of the research. ☐

4. I understand that data collected during this study, *could* be requested and looked at by regulatory authorities. I give my permission for any authority, with a legal right of access, to view data which might identify me. Any promises of confidentiality provided by the researcher will be respected. ☐

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6. I agree to the data I contribute being retained for any future research that has been approved by a Research Ethics Committee.

7. I agree to take part in the above study.

Name of Participant:	**Date:**	**Signature:**
Name of Person taking Consent:	**Date:**	**Signature:**

***Note**: When completed, one copy to be given to the participant, one copy to be retained in the study file*

Appendix 4: UPR 16 Form

FORM UPR16

UNIVERSITY OF PORTSMOUTH

Research Ethics Review Checklist

Please include this completed form as an appendix to your thesis (see the Research Degrees Operational Handbook for more information

Postgraduate Research Student (PGRS) Information		**Student ID:**	UP819656
PGRS Name:	THUNYANUN THEERA-NATTAPONG		
Department:	SEI	**First Supervisor:**	Professor David Grant Pickernell
Start Date: (or progression date for Prof Doc students)		**1/10/2016**	
Study Mode and Route:	Part-time ☐ Full-time ☒	MPhil ☐ PhD ☒	MD ☐ Professional Doctorate ☐

Title of Thesis:	The RIS–University–Science Park Nexus: University Roles within an emerging peripheral region developing-economy innovation system – A study of the Chiang Mai University (CMU) Science Park in Northern Thailand
Thesis Word Count: (excluding ancillary data)	73,580

If you are unsure about any of the following, please contact the local representative on your Faculty Ethics Committee for advice. Please note that it is your responsibility to follow the University's Ethics Policy and any relevant University, academic or professional guidelines in the conduct of your study

Although the Ethics Committee may have given your study a favourable opinion, the final responsibility for the ethical conduct of this work lies with the researcher(s).

UKRIO Finished Research Checklist:

(If you would like to know more about the checklist, please see your Faculty or Departmental Ethics Committee rep or see the online version of the full checklist at: http://www.ukrio.org/what-we-do/code-of-practice-for-research/)

a) Have all of your research and findings been reported accurately, honestly and within a reasonable time frame?	YES ☒ NO ☐
b) Have all contributions to knowledge been acknowledged?	YES ☒ NO ☐
c) Have you complied with all agreements relating to intellectual property, publication and authorship?	YES ☒ NO ☐
d) Has your research data been retained in a secure and accessible form and will it remain so for the required duration?	YES ☒ NO ☐
e) Does your research comply with all legal, ethical, and contractual requirements?	YES ☒ NO ☐

Candidate Statement:

I have considered the ethical dimensions of the above named research project, and have successfully obtained the necessary ethical approval(s)

Ethical review number(s) from Faculty Ethics Committee (or from NRES/SCREC):		E485
If you have *not* submitted your work for ethical review, and/or you have answered 'No' to one or more of questions a) to e), please explain below why this is so:		
Signed *(PGRS)*:	ธันยนันท์ ธีรนัฐพงศ์	**Date:** 18/8/2019